lished Monthly by Reinhold Publishing poration, 330 West 42nd St., New York , N. Y., U. S. A. Ralph Reinhold, Chair- of the Board; Philip H. Hubbard, Presi- ; H. Burton Lowe, Executive Vice Presi- and Treasurer; G. E. Cochran, Vice ident and Secretary; William P. Winsor, e President; Francis M. Turner, Vice ident. Price 50 cents a copy. Payable in ance, one year, $4.00; two years, $5.00; e years, $6.00 in U. S. and Possessions, ada and Pan American Union. $2.00 ra for each year in all other countries. mit by New York Draft.) Copyright, 1948, Reinhold Publishing Corporation. Printed Lotus Press, Inc., 508 West 26th St., New k 1, N. Y. All rights reserved. Re- ered as second class matter Nov. 14, 5, at the Post Office at New York, Y. under the Act of March 3, 1879

Materials & Methods

VOLUME 27, NUMBER 5 • MAY, 1948

FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 37

ENGINEERING FILE FACTS

DEPARTMENTS

NEXT MONTH: Principles and Uses of Simulated Service Testing . . . The Through Hardening of Steel . . . Metal-Coated Plastics . . . Oil and Heat Resistant Synthetic Rubber . . . Lead-Indium Bearings for High Stresses . . . Magnesium Parts Can Be Joined by New Brazing Process . . . Characteristics of Aluminum Make It Suited to Outdoor Reflector Use . . . Wooden Dowels Solve Fixturing Problems in Brazing Steel Laminations . . . ELECTROPLATED COATINGS FOR METALS (Materials & Methods Manual No. 38)

The MATERIALS OUTLOOK...

THE SITUATION IN GENERAL—Recent developments in Washington are sufficient to cause metal users, producers and processors considerable uncertainty. What the future may hold is anyone's guess until a preparedness program is finally settled on. In the meantime, those interested in metals are wondering what effect the European Recovery Program will have on materials supplies.

According to Paul Hoffman, administrator of the Marshall plan, finished steel needed during the first year of the program will total 4 million tons, about 5% of our annual production. This should have little effect one way or another on our steel supply, since we have been shipping that much or more regularly. Total exports during 1948, including relief shipments, are expected to be less than during 1947.

One thing is certain. Any acceleration of our plane building program will have the effect of making more acute the current shortage of sheet aluminum.

GOVERNMENT STOCKPILING—Federal bureaus have asked Congress for additional appropriations to cover stockpile purchasing during the next year to raise the projected total to 750 million dollars. If this material were to be withdrawn from the market during a relatively short period, severe shortages and dislocations would result. Even though appropriations are granted, deliveries may be over a reasonably long period. The reason for pressure on appropriations at this time is that contracts cannot be let until the expenditure has been authorized by Congress.

DEMANDS ON STAINLESS STEEL—Expansion, which appears to be before the chemical process industries, will cause a constant demand for materials using large quantities of nickel, chromium, molybdenum and copper. Stainless steels used where contact with acids is anticipated have high contents of some of these elements. For economy of application and conservation of materials, designers and materials engineers will have to plan on using considerably more clad metals, using the high alloys only where direct contact with chemicals is involved. For the present there appears to be sufficient alloy stocks and furnace capacity to supply stainless steel needs.

PRICE RISE TO AID LEAD SUPPLY—Lead, which many industrial buyers now feel is almost as hard to get as tin, recently jumped in price to 17.5¢ a lb. While the additional cost may cause some hardship, it has had one important compensating reaction. Shortly after the price increase was announced, word came from Australia that shipments of refined lead from that country will be increased this year to 2½ times the total for 1947. Australia has promised 25,000 tons of refined lead during 1948; the price, including import duty, will equal domestic prices. Some users of both lead and tin now find that tin is easier to obtain than lead. Forecasts for a more abundant tin supply now seem more certain of coming true.

ALUMINUM CAPACITY—Leaders in the aluminum industry are urging the Government to assist producers in increasing capacity to at least one million tons a year—double the present capacity. Projected defense programs will be hampered by the scarcity of finished aluminum as well as a lack of raw materials stockpiles. Present operating capacity for aluminum is at the rate of about 643,000 tons per year. However, if sufficient

(*Continued on page 4*)

The Materials Outlook *(Continued)*

cheap electric power was available, idle plants now in existence could be reactivated with the effect of increasing current capacity by 235,000 tons. Aluminum consumption today is nearing the wartime peak with very little going into military aircraft and armament.

MANGANESE HIGH ON LIST OF STRATEGIC MATERIALS—In the minds of government materials experts, manganese is now the No. 1 strategic material in the United States. As long as trade difficulties or threatened trade difficulties between the U. S. and Russia exist, the situation is likely to remain in this state. Russia has been one of the chief producers of high-grade manganese. Present supplies are adequate but tight. The Government wants to buy up all surpluses of battery grade manganese, since this grade is too scarce to be diverted to steelmaking uses.

INCREASED PLATINUM PRICES—The heavy jumps in quoted prices of platinum are partially blamed on reduced shipments from Russia. However, an anticipated demand for electrical contact points, if the military aircraft program goes through, has also caused pressure which resulted in higher prices. It is questionable whether the "fright" buying is justified, since jet planes do not require contact points. Even if points are needed, silver-tungsten and other alloys will serve adequately. There seems to be ample platinum for industrial uses, if jewelry uses were not so heavy. Heavy jewelry demands have also had a bearing on the price situation. Present platinum prices are near their peak as far as modern history is concerned.

INCREASED TITANIUM METAL SUPPLY—Interest in metallic titanium has been heavy, but commercial quantities are still in the future. The Bureau of Mines Boulder City plant is planning to expand its production from the present 100 lb. per day to a ton a day before the end of 1948. At present the price of titanium metal is about $4 per lb.; government engineers believe that if a 20,000-ton plant could be built the price would fall to about 50¢ per lb. One private company is rumored to have a better and cheaper method of production than that used by the Government. At the moment this company's production effort is concentrated on titanium oxide for pigment use—a demand that is large and certain.

COPPER PRICE MAY RISE AGAIN—Canadian sources are predicting that copper will reach a price of 25¢ in the near future. Price, as this is written, is 21½¢ at home and slightly higher for export. Two domestic producers are known to be trying to keep the price down, but how successful they will be is open to question. In this country there is the feeling that the price rise rumor is not well founded. Market experts say that a similar situation—where a price rise was rumored—was at least partially responsible for the sustained demand for zinc.

ZINC TO CONTINUE TIGHT—Nothing appears in the forseeable future to ease the tight situation in zinc. Galvanizing, the biggest single use of zinc, is now taking 45% of all slab zinc. Indications are that this use will continue to demand large quantities of zinc. Zinc stocks are continuing to decline, indicating that present use is far in excess of domestic production plus imports. Both production and imports have been at record highs.

STEEL MILL SCRAP—Although there is considerable steel mill scrap in Europe, it is doubtful whether much, if any, will become available for our mills. Plans are to build up European steel mills, which will then need the scrap. In the long run this will probably be all to the good as far as the U. S. economy is concerned, since it will help to relieve pressure on domestic steel supplies.

AN EDITORIAL

Too Many Cooks

The place was in an uproar! Executive fists were pounding tables. Engineering blueprints were being rudely rattled in the faces of fuming foremen. Designers shouted unprintable epithets at toolmakers, and metallurgists said rude martensitic things about the heat treaters. Off in a corner a nice little secretary mused that this was certainly an odd way to run a business.

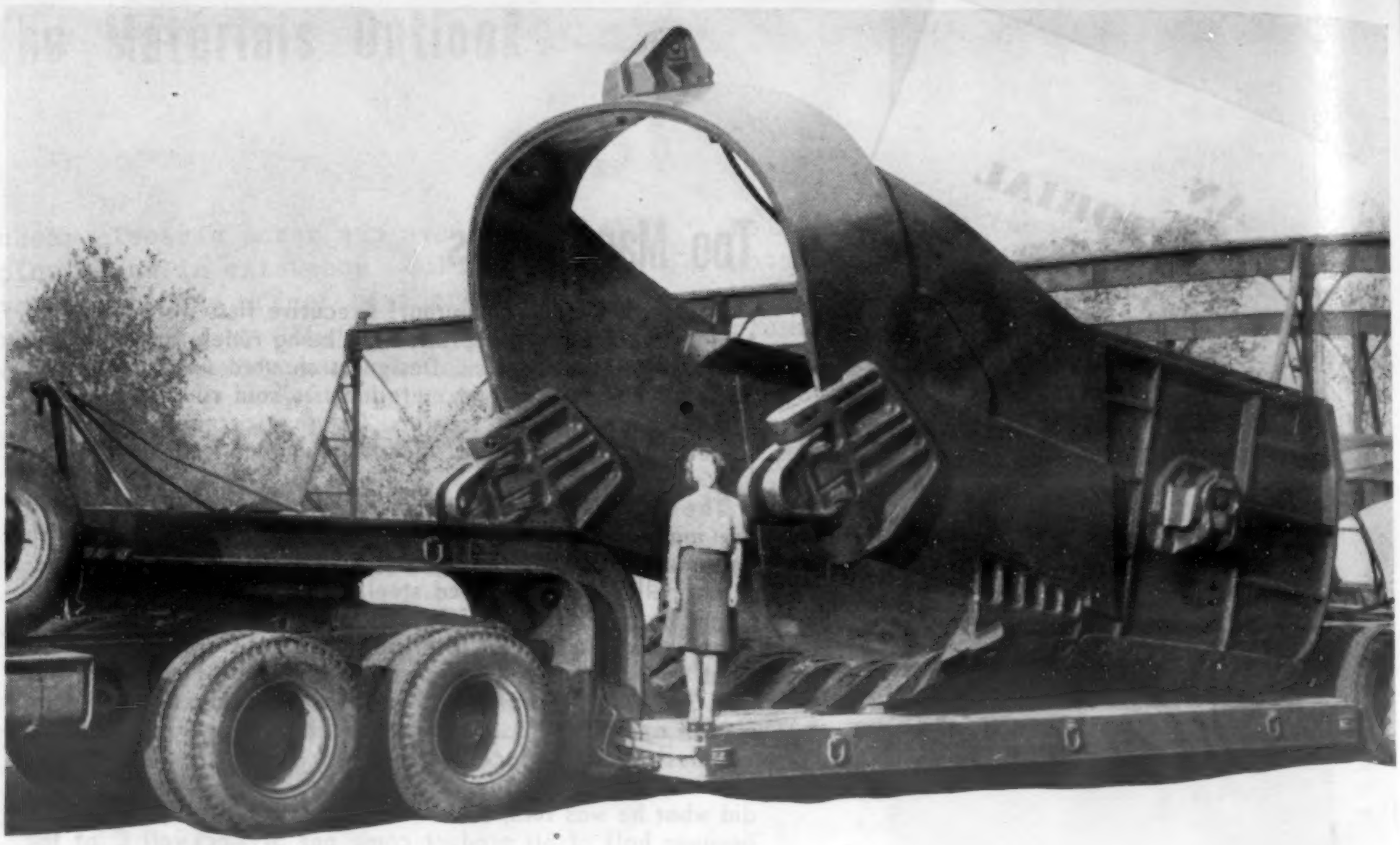
The cause of this not uncommon furor was a peck of trouble the machine shop was having getting an acceptable finish on some quenched-and-tempered A 3150 steel shafts. The blueprints called for "hardened steel." There had been three different materials supplied at various times; this 3150 was the latest—and the hardest. Everybody had a different idea about what was wanted. The designer would settle for anything that had 50,000 psi. endurance limit; the metallurgist insisted on a steel and heat treatment that would deliver 60 Rockwell C hardness at the surface of a 1-in. bar and 58 Rockwell C 1/2 in. from the end of a Jominy testpiece. The heat treater, who did what he was told, said what he was told couldn't be right because half of his product came out 57 Rockwell C at the surface. And when it was 60 either the machine shop foreman kept bringing dull tools back to the toolmaker or the inspector rejected the finish on the shafts.

Finally the general manager stopped abusing his fist on the table and delivered a decree. "What we need around here," he gently roared, "is somebody who is completely responsible for *materials*—somebody who can pick them out right as to how they'll stand up in our products, who knows how they'll handle in the shop, and who can work out these fabricating problems without tying up half the factory every time. We need a—a—a materials engineer—that's it! Jim, *you're* supposed to be the chief engineer; hire a good materials man, give him all the authority and responsibility he needs to do the job right, and by golly maybe we'll make something else besides conversation out of our materials!" (This was the sort of subtle wit that was responsible for the g. m.'s rise to the top in his company.)

Today that plant has a materials engineering *department*, with three men up to their necks in materials and their processing. There are still tumult and shouting and changes, but the circle of confusion has been sharply narrowed. When materials are originally specified, not only the designer's vital end-use requirements but also the processing characteristics are considered, and the final choices are made by someone who guarantees to see that the materials chosen will be economically and efficiently fabricated and treated.

This is the pattern that is spreading among industry's best managed plants—over half of them, in fact, are now operating in this fashion. Does *your* company have responsible materials engineering personnel?

FRED P. PETERS



World's Largest Dragline Bucket

. . . made of Inland HI-STEEL for greater resistance to abrasion, lower weight

IMAGINE a scoop that moves 25,000 tons of hardpan and shale . . . *every 24 hours*. That's just what this huge dragline bucket — built for a mid-western coal company by the Page Engineering Company — is doing.

When Page engineers designed this bucket, they faced the problem of finding a metal tough enough to resist extraordinary abrasion . . . yet light enough to handle effectively and economically, at least 30 cubic yards of earth per cycle.

To solve this problem, they chose Inland Hi-Steel. This low-alloy, high-strength steel provided the high resistance to abrasion they needed. Its high strength-to-weight ratio made possible the use of lighter gage sections without impairing strength.

They found that Hi-Steel could be worked as easily as ordinary carbon steel . . . without changing the fabricating equipment in their plant.

It will pay you to investigate Inland Hi-Steel if you have a problem calling for steel with a high strength-to-weight ratio, greater resistance to abrasion or corrosion.

To make more Hi-Steel available, other companies have been licensed to make this superior product. Write for Bulletin No. 11. INLAND STEEL CO., 38 S. Dearborn St., Chicago, Ill.

Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

Hi-Steel meets the requirements of SAE Specification 950

Available in Many Forms

INLAND STEEL

INLAND HI-STEEL

THE LOW-ALLOY, HI-STRENGTH STEEL

Practical Method Developed for Plating on Magnesium

by H. K. DE LONG, The Dow Chemical Co.

FOR MANY YEARS development work on plating processes for magnesium has been carried out. Processes were developed but up to the present time no process closely following procedures established for plating other metals had been developed. The process described in this article closely follows established plating procedures. The only difference is the addition of a simple preliminary immersion zinc coating step which is applied immediately after standard cleaning operations. The process is a patented development of the Dow Chemical Co. but will be licensed to qualified plating shops. By means of the newly developed plating process, nickel, chromium, cadmium, copper, brass, gold, silver and other metals have been successfully plated on articles made of magnesium.

Brightly polished magnesium surfaces exposed to the atmosphere without a protective lacquer will exhibit a tendency to tarnish quite readily. This tarnish is a minor form of corrosion and is not harmful except from an appearance standpoint. Many other common metals in daily use are likewise subject to this surface tarnishing. Portable tools, costume jewelry, household appliances and the like would offer an interesting field of use for magnesium and one in which its lightness would be appreciated if a permanent, bright metallic finish were available.

The apparent reason that magnesium has been difficult to plate under plant conditions is the formation of a hydroxide film which forms on the magnesium surface in any aqueous bath. The metal, as it comes directly from a cleaning pickle, will be coated with this film. Development of the procedure for electroplating magnesium had to achieve the elimination of this film during the preliminary cleaning of the piece, and to maintain the surface in a film-free condition during the beginning steps of the plating. To accomplish these results, cleaning methods were devised that would minimize the film forming propensities of magnesium. To maintain this clean surface during the first moments of immersion in the electroplating baths, it was decided to lay down a protective film of zinc, just as the electroplating of aluminum may be accomplished by first depositing a flash coat of zinc, and laying down a plate of the desired metal over this base. A deposit of zinc could be formed on the surface of the magnesium without the help of an electric current, and this deposit when applied under such conditions as favored formation of a tightly adhering, non-porous film, became the basis upon which subsequent electrodeposits could be made. Indeed, after the conditions for cleaning the metal and depositing the film had been established, the electroplating of magnesium was no more difficult than the electroplating of zinc.

The Dow process for the electroplating of magnesium consists of three principal operations: (1) Surface preparation of the work piece usually a combination of mechanical and chemical cleaning, (2) zinc coating by deposition from a bath without the use of electric current, and (3) electroplating with the desired metal in the usual way.

Surface Preparation

The surface must be free of nonmetallic contamination such as the normal oxides, inclusions of oxide, mill scale, dirt, graphite base lubricants as used in forming and drawing, oil, grease, and previously applied chemical treatment coatings. To insure the removal of foreign materials of the above nature, the parts are first degreased and pickled prior to any mechanical operation. The initial pickle tends to remove surface contamination and prevent it from

being further imbedded, or partially covered up, during subsequent polishing and buffing operations. It is also important to pickle parts that are not buffed over-all so as to prepare the unbuffed surface for zinc coating. The zinc coating will not adhere satisfactorily to as-cast or as-wrought surfaces, in general, unless reasonably free of nonmetallic contamination.

A. The parts are solvent degreased, if heavy oil and grease coatings are present on the surface by either:
  - A-1 Vapor phase degreasing, using chlorinated solvents.
  - A-2 Solvent emulsion cleaning, using a petroleum base solvent and an emulsifier.
  - A-3 Simple solvent rinsing in naphtha, Stoddards Solvent, Varsol, etc.

B. Alkaline clean by soaking for 3 to 15 min. in a high pH cleaner such as the following at 180 to 212 F:

Sodium carbonate (soda ash) 3 oz.
Sodium hydroxide (caustic soda) 2 oz.
Soap or wetting agent 0.05 to 0.1 oz.
Water to make one gal.

(Proprietary alkaline cleaners as used for steel are satisfactory for cleaning magnesium in this operation.)

B-1 Rinse parts after cleaning in running water.

C. *Pickling* (prior to buffing if metal is oxidized or has a chemical coating)

Sand, permanent mold, and die castings are pickled for 1 to 3 min. at room temperature (70 to 90 F) in an aqueous solution containing:

75 to 85% by volume H_3PO_4 (phosphoric acid)

Containers for this solution can be of crockery, stainless steel or mild steel tanks lined with rubber, or synthetic materials such as "Tygon", "Koroseal" and "Saran".

Sheet, extrusions, forgings, and sheet formed parts are pickled for ½ to 2 min. at room temperature (70 to 90 F) in the following water solution:

20% by volume CH_3COOH (glacial acetic acid)
5% by weight sodium nitrate ($NaNO_3$)

Containers for the acetic acid-nitrate solution may be constructed of crockery, pure aluminum, mild steel coated with rubber, or a synthetic lining such as "Tygon", "Koroseal" and "Saran".

C-1 Rinse thoroughly in cold water followed by a hot rinse to facilitate drying.

C-2 *Optional Rinse:* If black powder deposits, water streaks, or general light smutting of surface occurs, the parts are dipped in a water solution containing 8 to 12 oz. per gal. sodium hydroxide (caustic soda) immediately after pickling and before water rinsing. The parts are then water rinsed as shown in C-1. The caustic soda bath is preferably operated warm (140 to 180 F).

D. *Mechanical Operation*

If a final smooth, highly polished surface is desired the parts are now polished and buffed or, in case of small parts, may be tumbled and burnished. Otherwise, where bright deposits are not required, the plating procedure can be carried out without these operations.

E. Solvent degrease as previously described, if parts are covered with buffing compound or heavy oil and grease films.

F. Soak clean for 3 to 5 min. at 180 to 212 F in an aqueous alkaline cleaning solution of the following composition:

8 oz. per gal. (6%) tri-sodium phosphate ($Na_3PO_4 \cdot 12\ H_2O$).

At the end of the soak cleaning period it is preferable to anodic clean the parts for 10 to 20 sec. at 6 v. The anodic cleaning tends to deplate any possible heavy metal deposits that might be present on the work formed in the soak cleaning period. The anodic cleaning should not be prolonged longer than indicated as the work will become hydroxide coated and a longer subsequent pickling time is required to break down this coating.

F-1 Rinse in running water.

G. Pickle for 15 sec. to 1 min. at room temperature (70 to 90 F) in the following aqueous solution:

1% by volume hydrochloric acid (HCl).

Tanks for this solution should be of crockery, rubber lined steel, or synthetic rubber coated steel of such lining materials as "Tygon", "Koroseal" or "Saran". Uncoated metal tanks should not be used as a slight dissolution of heavy metal salts due to a mild attack on the tank may result in loose smutty immersion deposits of these metals on the work.

This solution is satisfactory for all aluminum containing magnesium alloys. It is not, in general, satisfactory for pickling Dowmetal M alloy (Mg-1.5 Mn) as a dark smut is sometimes left on the surface. For Dowmetal M alloy a solution containing 1% acetic acid ($CH_3 \cdot COOH$) should be used instead.

H-1 Rinse in cold running water.

Special Note: The above pickling solutions are designed to serve as surface activators and will remove thin hydroxide coatings. It is not intended that they be used to remove heavy oxide, oxide inclusions, chromate type chemical treatments and the like. The pickles previously described under "C" are for these purposes. The pickling period in the activator pickles should be for a sufficient time to remove all passive areas on the surface and can be kept to a minimum consistent with obtaining a uniform overall etching as noted by visual observation.

Immersion Zinc Coating

Immerse parts immediately while wet from rinsing in an aqueous bath for 3 to 5 min. (5 min. for all aluminum containing alloys; 3 min. for Mg - 1.5 Mn alloy) at 170 to 180 F while the solution is being agitated by mechanical stirring:

120 gm. per liter tetrasodium pyrophosphate ($Na_4P_2O_7$)
40 gm. per liter zinc sulfate ($ZnSO_4 7H_2O$)
10 gm. per liter potassium fluoride (KF)
5 gm. per liter potassium carbonate (K_2CO_3)
pH = 10.2 — 10.4

The carbonate is added to adjust the pH of this solution from 9.8 to a value between 10.2 to 10.4. More or less carbonate may be required than the

amount shown. The exact amount added should be determined by pH measurements.

This bath must be made up with water relatively free from iron salts. Therefore, it is preferable to use distilled or de-ionized water. Good commercial grade chemicals which are low in heavy metal salts as impurities, such as iron or copper, can be used. The optimum time of treatment may vary slightly from one alloy to another but should not be less than 3 min. nor more than 7 min. Both a prolonged treatment and too short a treatment will result in inferior adhesion of subsequent electrodeposits.

Stainless steel is preferred as a tank material for holding this solution in production use. Mild steel should not be used. Rubber lined steel, Monel, or nickel tanks may also be satisfactory. The heating coil, if steam is used for heating, should also be of stainless steel.

The zinc immersion bath should be prepared by first adding and dissolving the zinc sulfate in water at room temperature. The solution is then heated to 120 to 140 F and the tetrasodium pyrophosphate added. A fluffy precipitate will form which will dissolve after stirring for a few minutes. Once the precipitate is completely in solution the potassium fluoride is added and then the carbonate to adjust the pH. Rinse parts in cold running water, or spray rinse after zinc coating. Do not use a hot water rinse.

Copper Strike

Copper strike immediately in a copper cyanide-Rochelle salt bath operated at 115 to 120 F and of the following composition:

5.5 oz./gal. (41.3 gm./l) copper cyanide
6.8 oz./gal. (50.8 gm./l) sodium cyanide
4 oz./gal. (30.0 gm./l) sodium carbonate (soda ash)
6 oz./gal. (45.0 gm./l) Rochelle salts
0.25 oz./gal. (1.9 gm/l) sodium thiosulfate (hypo)

Free sodium cyanide — 0.75 oz./gal. (5.6 gm./l)
pH = 10.0 — 11.0 (preferably 10.0 to 10.5)

Electrical contact is made quickly and a low current density of 5 to 10 A./ft.^{2} is applied for the first 2 to 3 min. After this 2- 3-min. initial deposition the current density is increased to 15 to 20 A./ft.^{2} and deposition continued for at least 5 min. Rinse in water. Do not hot water rinse if preceding another plating operation.

Copper

Copper can be plated in heavier deposits by prolonging the plating time in the above bath, or by transferring the work to other alkaline type cyanide or pyrophosphate baths. Proprietary bright copper plating baths are quite satisfactory for building up the copper plate thickness. The "MacDermid Bright Copper Plating Solution" has been quite satisfactory and good results have been obtained using the "du Pont High-Speed Copper Plating Bath". The "Unichrome Copper Pyrophosphate Bath" must be modified by the addition of 8 oz. per gal. potassium fluoride (KF) for best results, particularly on parts of complicated shape. This solution tends to attack magnesium, and unless the parts are completely covered with copper from the strike bath, or fluoride is added to inhibit this attack, rough deposits will result. Plating for 15 to 20 min. in this copper strike bath will permit the copper pyrophosphate bath to be used without the addition of fluoride. Cyanide type baths do not readily attack magnesium and can be used over thin copper strike coatings without modification.

Nickel

Nickel can be applied from any of the conventional baths. It is preferred that the nickel bath have a pH of about 4.0 or above. The "Udylite Bright Nickel Process" operated at a pH of 4.0 to 4.8 is very satisfactory. Watts type dull nickel baths have also been used satisfactorily at a pH of 5.3 to 5.8. A copper plate of about 0.0005 in. thickness, particularly on complicated parts, must first be applied to prevent attack of the magnesium through the pores in the copper plate.

Cadmium and Zinc

These metals have been applied directly over the zinc immersion coating from standard cyanide baths. An initial copper strike, or copper plating, produces better results than application directly over the zinc immersion coating.

Brass

Brass may be applied directly from a standard cyanide plating solution, or applied after copper striking.

Silver

Silver may be applied from conventional cyanide baths after applying a copper coating of about 0.0003 in. Plating silver directly over the zinc coating is only fairly successful.

Chromium

Chromium has been applied directly to the zinc immersion coating in standard baths but the adhesion of the chromium deposit has not as yet been satisfactory when applied in this manner. Copper-nickel-chromium deposits may be satisfactorily applied.

In general, various combinations of electrodeposits are possible, but these usually depend upon the initial deposition of copper over the zinc immersion coating.

Racks

Copper, or copper plated steel racks are preferred. Magnesium alloy racks may also be used. It has been found that when magnesium is in contact with other metals an electrolytic effect occurs that interferes with a proper zinc film being formed in the zinc immersion bath. Copper also takes the zinc film in this bath immediately (when in contact with magnesium) and, therefore, this cell action is averted. The racks must be used only for copper plating, or given a copper strike on exposed surfaces after used in electrodepositing metals other than zinc or cadmium. Organic rack coatings must be used to confine the exposed rack area to an absolute minimum for electrical contact with the magnesium part.

Announcing

A NEW, SIMPLER, MORE IMPORTANT

Materials & Methods Achievement Award Plan

After two years' experience with the Materials & Methods Achievement Awards, the publishers and editors of MATERIALS & METHODS are happy to announce a new step forward in the Award program. Heretofore the Award has been a "contest" in the sense that the achievements considered had to be formally "entered" by their sponsors, and our Judges then made their choices of the winners from these entries alone. Beginning with the 1948 Awards, the judges will confer the Award for that achievement in our field which in their opinion is most worthy, whether or not it has been formally entered as a candidate for this honor. The new type of award will therefore not be subject to the criticism, which inevitably arises, that many highly eligible achievements were not considered for the Award because they were not "entered" by those responsible for them.

THE AWARDS OF PREVIOUS YEARS

Our readers will recall that the Materials & Methods Achievement Award was established to foster and encourage skilful and enlightened use of materials in product manufacture by honoring those doing outstanding work in the application, processing and development of engineering materials. In past years the awards in each year were made for achievements that fitted a "theme" or solved a problem especially distressing that year.

1946

The 1946 Achievement Award, the winners of which were announced in our November 1946 issue, comprised a First Award and five Honorable Mentions *for outstanding achievement in applying war-born knowledge of materials and their processing to peacetime production.* The First Award went that year to J. O. Almen of General Motors Corp. for his excellent work on shot peening and other pre-stressing methods. Honorable Mention Awards were conferred on Jack & Heintz Precision Industries, Inc., Haynes Stellite Co., Martin Fleischmann of Timken Roller Bearing Co., Sapphire Products Div. of Elgin National Watch Co. and Solar Aircraft Co. for specific wartime developments which were being applied in peacetime to exceptional advantage. These Awards were presented to their winners in Atlantic City on November 20, 1946.

1947

The 1947 Awards were announced in our November 1947 issue. For 1947 the special "theme" was *cost reduction* and awards were for materials engineering achievements of one kind or another which increased the production or lowered the cost of products then being manufactured. The Grand Award went to Dr. Cledo Brunetti of the National Bureau of Standards, for his development of printed circuits for electrical and electronic products. Special Awards were made to Latrobe Electric Steel Co. and jointly to Republic Steel Corp. and Arthur D. Little, Inc. for a new material development and for a new process development, respectively, which boosted production and lowered cost. Honorable Mentions were also granted to a group of engineers at the National Bureau of Standards (Peters, Emerson, Nefflen, Harris and Cooter); to Thermex Div. of the Girdler Corp.; to Westinghouse Electric Corp.'s Motor Div.; to Rigid-Tex Corp.; and to T. E. Eagan of Cooper-Bessemer Corp. The 1947 Awards were presented in Chicago on October 22d.

In both previous years the winners were selected by an independent group of seven nationally-known engineers and executives, the publishers and editors of this magazine having no influence whatever on the voting. Plaques and Certificates were given to the award winners each year.

THE NEW AWARD PROGRAM

Starting with the 1948 Award, although the basic objective of the award program will remain the same, the character of the Award and the breadth of its importance will, we think, be greatly improved by changes to be made in it.

Henceforth the Materials & Methods Achievement Award will be simply an annual award for the outstanding materials engineering achievement of the year in which it is given. Our judges will decide what company or individual during the previous 12-month period has made the greatest contribution to the advancement of materials engineering (which we are defining broadly as the application of engineering materials to product manufacture). No entries will be required, although we and the judges will welcome having specific developments or achievements called to our attention by anyone interested in them.

There will be no pre-specified "theme" or temporary objective in which achievements must fall, as has been required in previous years. All outstanding recent materials engineering achievements will be considered broadly for the contribution they have made to industry as a whole or to the field of materials engineering in particular. The conferring of special awards or honorable mentions in addition to the Grand Award will be left to the discretion of the judges. As in previous years the publishers and editors of this magazine will have no vote in the judges' decision and of course the awards will be granted without regard to whether the candidates are subscribers to or advertisers in MATERIALS & METHODS.

The type of achievements to be considered may include any of the following:

Broad materials engineering systems or programs employed by certain manufacturers;

Outstanding applications of engineering materials to improvement of product quality or production cost;

Development or application of processing methods exceptionally applicable to certain materials which greatly enhance their usefulness in industry;

Development of new materials which represent a major contribution to the field;

Special research on materials or processing methods for them which provide a long step forward in our knowledge or application of engineering materials;

The solution by an individual or an organization of a major problem in the materials engineering field, which represents an outstanding contribution to better product manufacturing;

Any other achievement of an exceptional and broadly applicable nature which falls squarely within the field of materials engineering.

The independent Board of Judges that will select the 1948 achievement in materials engineering most deserving of this Award is now being appointed and the names of these highly competent and well-known men will be announced in an early issue. Since there are no "entries" required there is no formal "closing date" of this award program. However the achievements and developments to be considered by the judges will be those which have been announced or presented to industry or whose impact was especially felt in the period roughly from the middle of 1947 to the end of 1948. As a deviation from former years the Award will be announced and presented in the early months of the following year (1949 in this case) rather than in October or November of the current year.

SUMMARY

The Materials & Methods Achievement Award has thus been graduated from the "contest" category to a broad engineering award for highly meritorious achievement in the materials engineering field whether sought by its recipient or not. The caliber of the achievements to be considered may also be broader and more important in nature since they no longer need be tied down to a specific type of development "theme" or immediate objective. The basic purpose of the Materials & Methods Achievement Award Program remains to foster and encourage skilful and enlightened use of materials in product manufacture. For 1948 and thereafter the Award will be made each year for that achievement which, in the opinion of an unbiased independent committee of engineers, represents the outstanding materials engineering achievement of the previous year.

We hope that many of our readers will call to our attention any important developments or achievements which they feel are distinctly worthy of consideration for this high honor by our judges. You may be sure that we will forward such suggestions to the Board of Judges, who will give them most careful consideration. Please address all correspondence or inquiries concerning the Materials & Methods Achievement Award to Fred P. Peters, MATERIALS & METHODS, 330 West 42nd Street, New York 18, N. Y., who is the non-voting secretary of the Materials & Methods Award Committee.

Tubular, cylindrical and other symmetrical forms in steel can be produced by a process which resembles impact extrusion, except that more steps are required.

Steel Shapes Formed by Cold Extrusion

by KENNETH ROSE, Engineering Editor, Materials & Methods

AMONG THE BENEFITS the United States has derived from the recent war are the use of certain results of German research, both by freeing of German patents for use by American manufacturers at nominal fee, and by the investigations of German industrial techniques made by American experts. Some of these experts, in uniform, moved into Germany with the first of the United States troops to enter that country, and others have searched through plants and records since our occupation to find anything of value to American industry.

One of the more promising of these discoveries in the metal forming field is a process used by German engineers to form steel, cold, to shapes usually produced by hot forming methods. The procedure has been called cold extrusion, or cold shaping, or some-

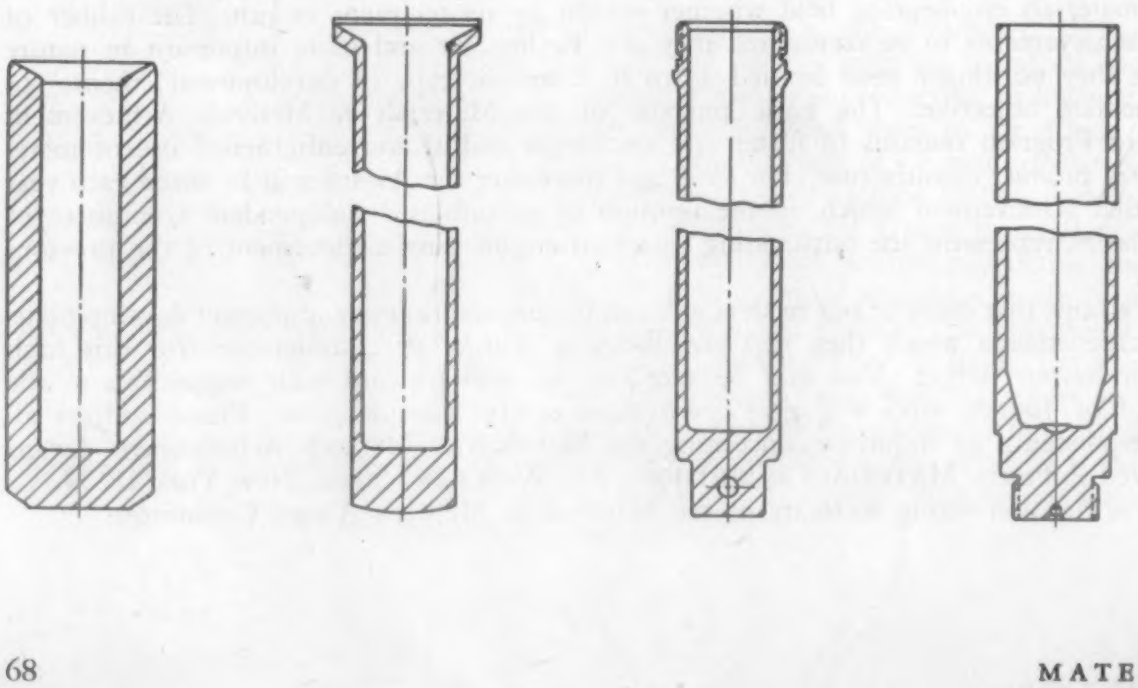


Fig. 1—After a preliminary extrusion, shown in the left, the piece may be given a variety of forms.

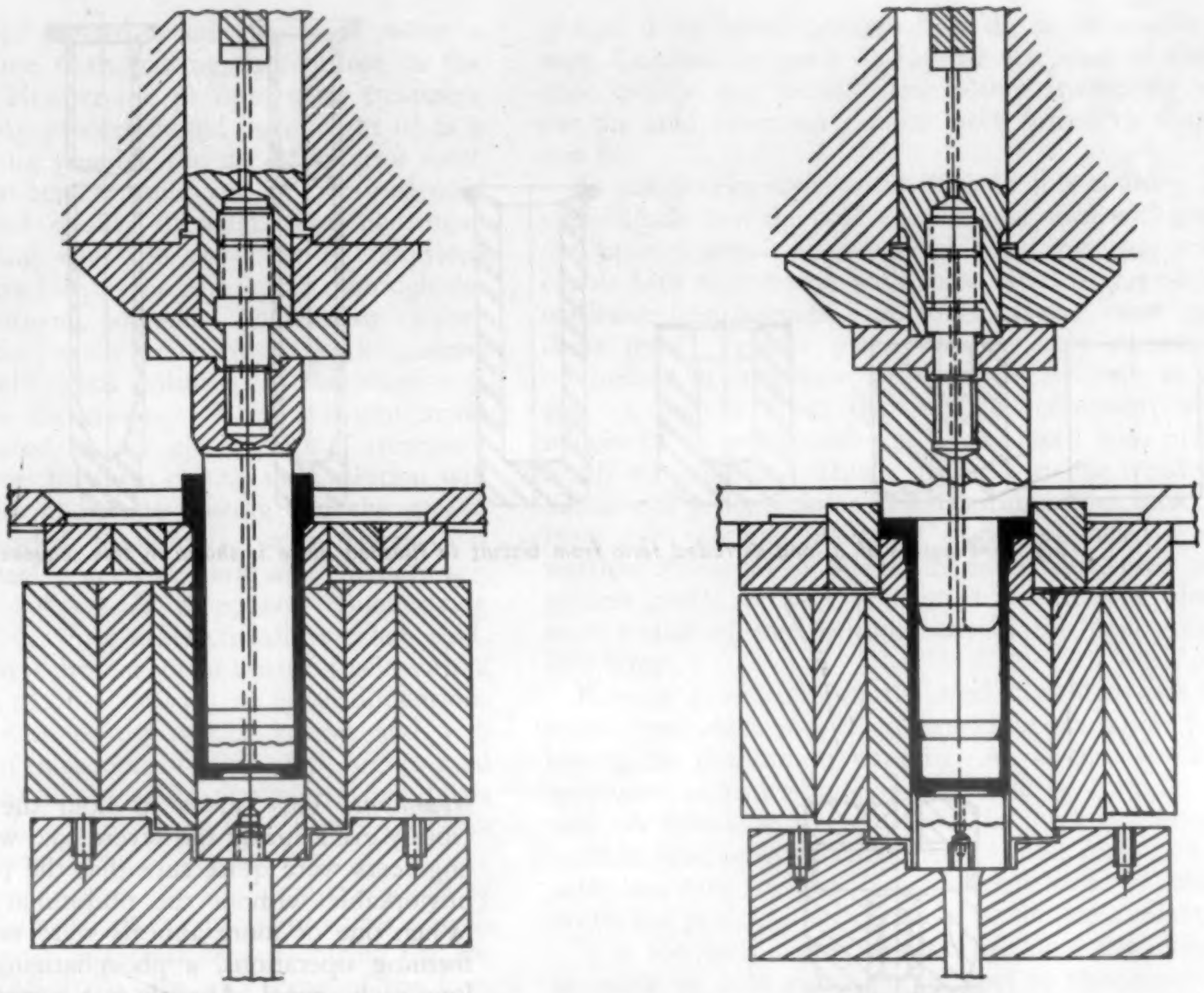


Fig. 2—Another multi-step process accomplishes the forming of this part, in which a counter-action punch regulates the bottom of the piece and also presses the top flange.

times cold forging. It closely resembles the process called impact extrusion, familiar in this country in fabricating some of the softer metals, such as tin, lead and aluminum, with the difference that the steel is made to flow under steadily applied force, without impact. The punch is stopped about 1/8 in. from the workpiece, and the extrusion takes place with the slow travel of the punch from that position.

In the German variation of the impact extrusion process, steel was made to flow, cold, into die cavities and about a mandrel or punch, much as the softer metals had been used in this country and abroad. While impact extrusion of the soft metals has been a one-step process, the application to steel has frequently meant multiple-step forming. Engineers from Heintz Manufacturing Co., Philadelphia, investigated the process abroad for the OTS, and are continuing its study in this country. American research has already gone beyond that done in Europe, and, with the help of the better steels available here, results have surpassed those obtained in Germany.

Impact extrusion of the soft metals has started with a pellet or small biscuit of the metal, and has squeezed it into the cavities of a die by the action of a punch, or mandrel, with the excess material flowing out of the die to take a tubular form around the mandrel. The cold shaping process used for steel starts with a biscuit cut from bar stock or punched from sheet or plate. This is squeezed into die cavities, and sometimes annealed and again formed as a part of the shaping process. When the piece has been formed completely within the dies the process resembles cold die forging, if the contradiction in the use of the terms "cold" and "forging" together can be overlooked. Usually, the process involves squeezing the steel out of the mold, with the punch serving as a mandrel, and here the method is a true extrusion of the steel.

Multiple-step forming has made possible a greater variety in the finished pieces that can be produced by this process. There are pieces in which a flanging operation follows the extrusion of the tubular portion. Other examples are a piece extruded at both ends, and another in which several successive extrusions are made to produce a very long tube.

It is important to recognize that the method is concerned with tubular, cylindrical, or other symmetrical forms. It may have a limited application in the production of seamless tubing, though German engineers seemed to agree that American methods were the more economical when long runs were to be made. It has been suggested as a means of producing wire and other small cylindrical items, and for the forming of small pieces to close tolerances.

Several features of the process are:

(1) *The material is always given a phosphatizing*

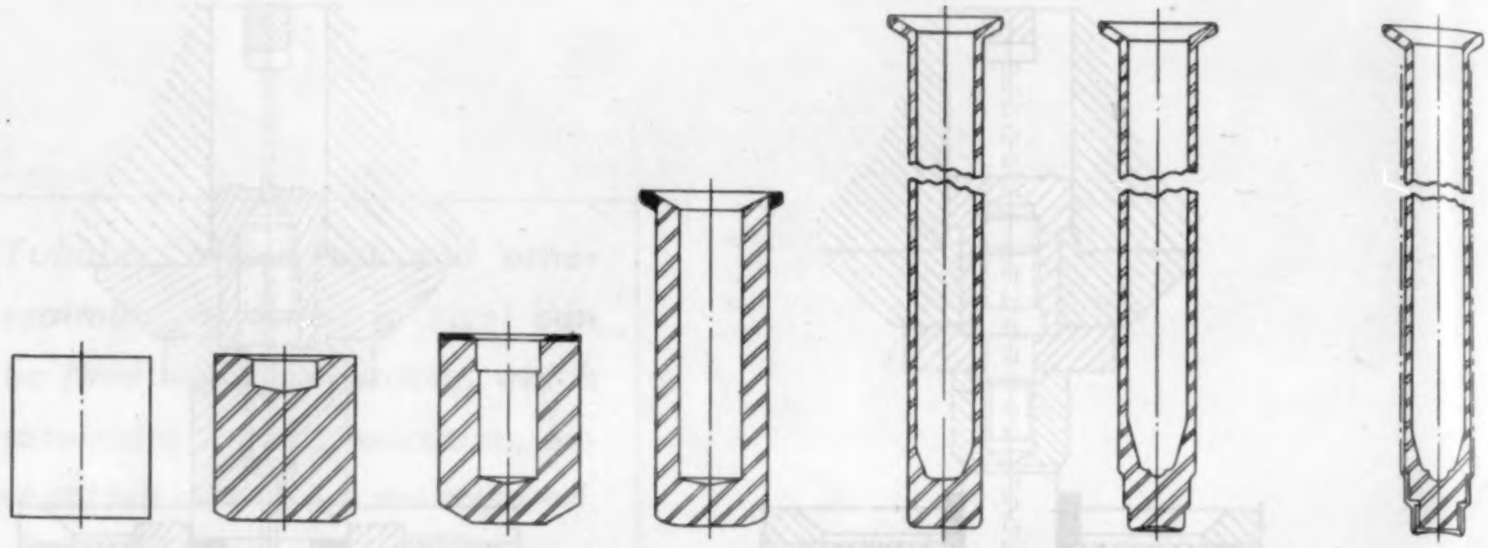


Fig. 3—Progress of a long extruded form from biscuit to finished piece is shown in this sequence.

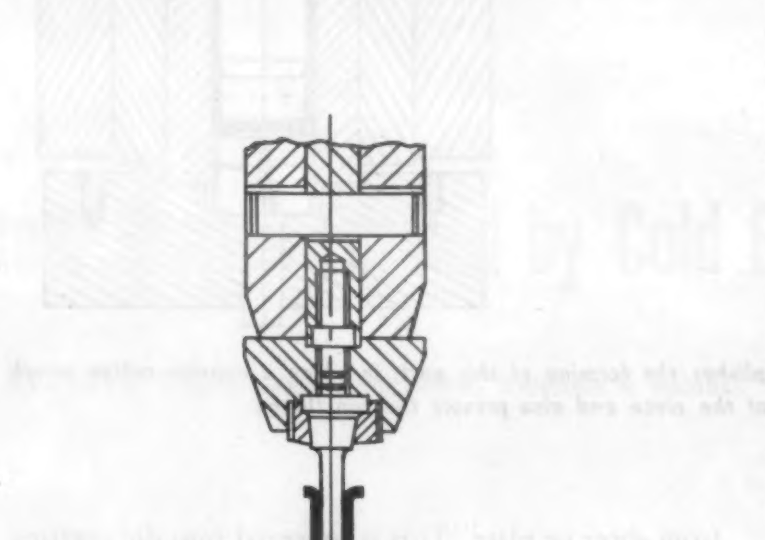


Fig. 4—Extrusion of a long, slender form is possible with the use of a punch of the proper type and guide bushing.

treatment. This serves to hold the lubricant tenaciously even during the severe cold-working. German engineers were quite sure that the process would be unworkable without the preliminary phosphatizing. When one or more anneals were necessary between forming operations, a phosphatizing treatment follows each anneal. Anneals may sometimes be omitted if phosphatizing is repeated between steps, they said.

(2) *Forming usually starts with a cupping operation, as for deep drawing, and may involve a series of steps.* The sequence of operations depends upon the final form to be obtained, but the pressing of a cup and extruding the tube in several steps may be considered typical of the process.

(3) *The steel is formed to close tolerances, and usually to final form.* Dimensions may be held to within about 0.001 in., and the surface is such that machining may be omitted for many applications.

(4) *The work may be done on standard presses.* Reports from the engineers investigating the process in Germany and continuing the study in this country indicate that, though pressures are high, the presses need not be of tremendous size. Their development work has been done on various standard presses, ranging in size from 25-ton to 2500-ton capacities.

Phosphatizing has been used increasingly in this country as an aid to drawing when difficult draws are to be made. Use of the process in tube drawing has become widespread, and today probably most of the cold-drawn seamless tubing produced has been phosphatized during its fabrication. It has been found possible to make difficult draws with phosphatized sheet that could not have been accomplished with the untreated material, and probably one of the reasons for its wider use in Germany was the necessity of producing pressed metal parts with inferior steel. Use of this treatment was said to be so general in Germany that the process of drawing the steel so treated was called bonderdrawing.

Phosphatizing is helpful in the cold extruding of

steel, as in other pressed metal operations, when a good surface, free from scoring, is required in the finished piece. Neither the phosphatizing treatment nor the extruding process should be thought of as a means for making possible the use of inferior steel, however, as satisfactory results can be obtained only by using a good quality material. The phosphate coating remaining after the extruding is completed is a good base for lacquer or paint after thorough degreasing with organic solvents. An alkaline cleaner should not be used when the coating is to be retained as a base for additional finishing, as the alkali will tend to dissolve the coating. When a bright metal surface is required, as for electroplating, treatment for a few minutes in warm caustic soda solution will remove both the phosphate coating and the grease.

In an article titled "Phosphating as an Aid in Cold Forming of Steel," in *Korrosion und Metallshutz*, June, 1941, H. Faber & H. Kopp say: "Bonderizing makes possible drawing of electrically welded, cold-drawn precision tubes of open-hearth steel with a tensile strength of 50-57000 psi. to finish dimensions in five draws, without any process anneal, and with a total reduction in section of 69%. Still higher total reductions, up to 80%, can be attained in five draws with seamless drawn precision steel tubes of chromium-molybdenum steel."

The steel most used in the foreign applications of the cold extruding process is equivalent to SAE 1010. Development work at Heintz Manufacturing Co. has made use of SAE 1010 also, and some of the low-alloy steels have been found to be suitable. A careful annealing of the steel before processing is important if the extruding process is to be severe.

German designs permitted about 1-deg. draft on long tubular forms, and about 2 deg. on shorter lengths. These values should not be accepted as limits for the process, however, for American study has indicated that they could be reduced if necessary. A factor in the progress of American studies of the process is the better quality of the die steels available here. German die steels during the war were of such poor quality that some of the plants attempting to use the cold extrusion process were forced to abandon it.

As the development takes form in this country, it seems likely that the cold extrusion of steel will give the pressed metal manufacturer a process that will enable him to compete with some types of gray and malleable iron castings, drop forgings, and screw machine parts. Tubular parts made by cold extrusion on presses of moderate size will be accurate as to size, of such a finish that surface refinement will seldom be necessary, and will be produced with practically no scrap loss. This is in line with the trend of industry to process closer to finish dimensions directly from raw material. German engineers, faced with wartime shortages of practically everything, used the process partly because it formed the desired piece from a disk of steel without any of the steel going into scrap.

Foreign production of the steel cartridge case in some cases made use of an extruding operation following the preliminary cupping. An aircraft landing gear used an hydraulic cylinder made by cold extrusion. A fuze base was produced in three operations by this new pressworking method, and many other parts less easy to identify have been listed in blueprints and process sheets as made by the same method.

It is too early to list specific products that might be made by cold extrusion of steel in this country, as research is still being done to determine how far the process may be carried. Tubular and other cylindrical products in general can be considered within the field to be explored. Progress of the research being done seems to offer a possibility that cold extruded steel parts may become a commercial reality within about a year. The ingenuity of the American tool engineer may be counted upon to produce dies that will realize the full possibilities of the process.

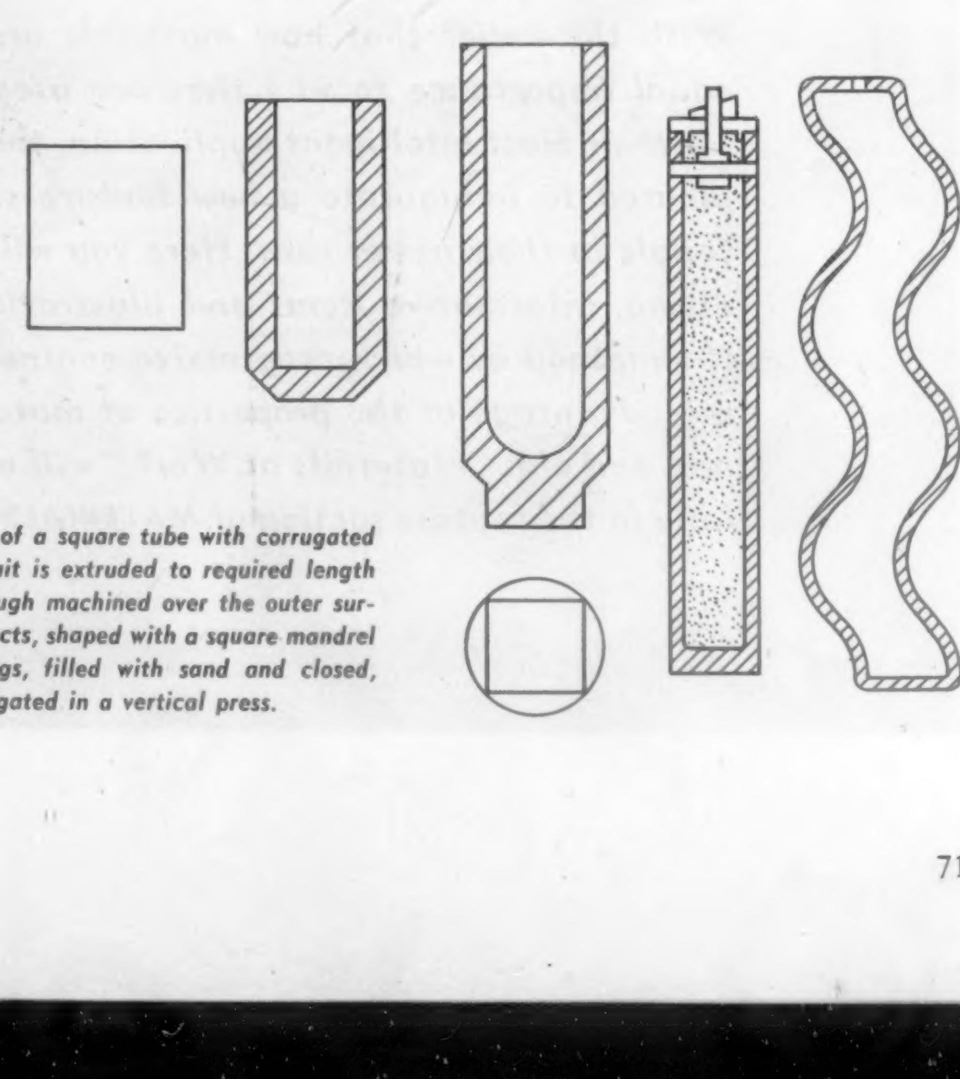


Fig. 5—Production of a square tube with corrugated sidewall. The biscuit is extruded to required length in several steps, rough machined over the outer surface to remove defects, shaped with a square mandrel through square rings, filled with sand and closed, then corrugated in a vertical press.

Materials at Work

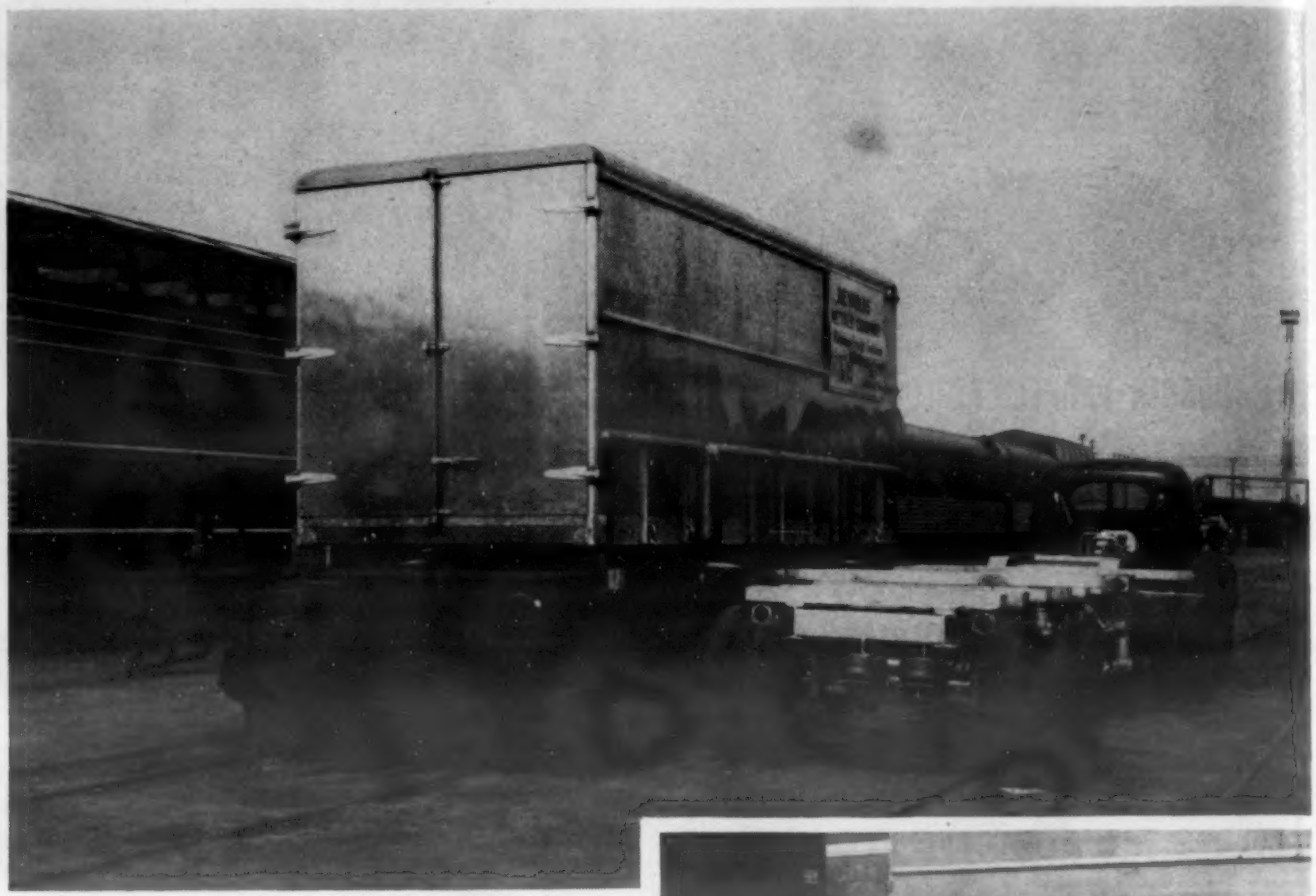
MAGNESIUM AIRCRAFT SKIN *Although magnesium has been used on aircraft control surfaces and for many aircraft parts, one of the first uses of magnesium sheet as the fuselage skin of a plane is now reported. The plane involved is the Douglas-built Navy Skyrocket. The magnesium alloy skin, about 1/10-in. thick, is fastened over an aluminum alloy frame. In this application, the structural strength and rigidity of magnesium were more important than the weight saving. In creating the required shapes, extensive use was made of stretch forming techniques in which preheated magnesium sheet is formed to desired contours by stretching it over a heated die. The plane is rocket and jet powered.*

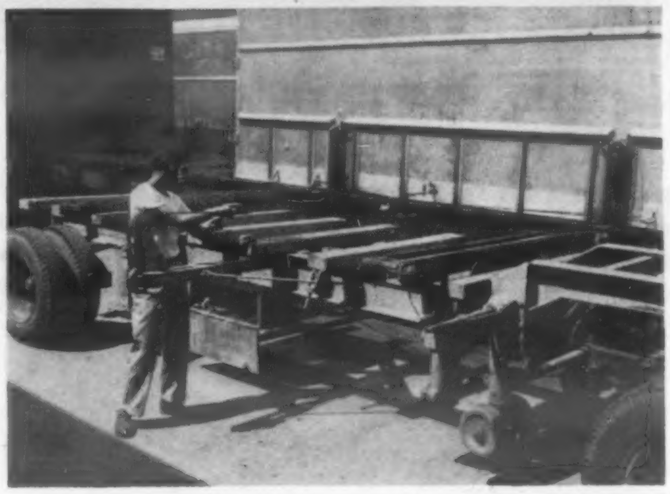
With the belief that how materials are used is of equal importance to why they are used as a basis for their most intelligent application, the editors are pleased to inaugurate a new feature showing materials in their newer uses. Here you will find interesting, informative items and illustrations showing the method by which progressive engineers are taking advantage of the properties of materials—both new and old. "Materials at Work" will appear regularly in the feature section of MATERIALS & METHODS.

RUBBER PROPELLERS *A propeller for outboard motors which presents a rubber surface to the water has been developed by the molded goods division of Goodyear Tire & Rubber Co. The rubber covers a metal core of cast aluminum or bronze. While stiff enough to cut the water, the rubber prop is said to be sufficiently resilient to slide over weeds without fouling and to bounce over driftwood and other obstacles without shearing the drive shaft pin.*

CORROSION PROOF MOTOR *Monel, cast bronze and brass are used in a new electric motor which is designed to be used under corrosive conditions. Monel, 3/32-in. thick, is used for the outside shell of the motor and for the fan cover. Cast bronze is used for the motor fan, replacing cast aluminum. Bronze is also used for shaft collars, and brass has been chosen as the material for grease pipes. The Reliance Electric & Engineering Co. is making this motor for service where might be present such hazardous atmospheres as those caused by gasoline, oil, naphtha, alcohols, acetone, lacquer solvent vapors and natural gas.*

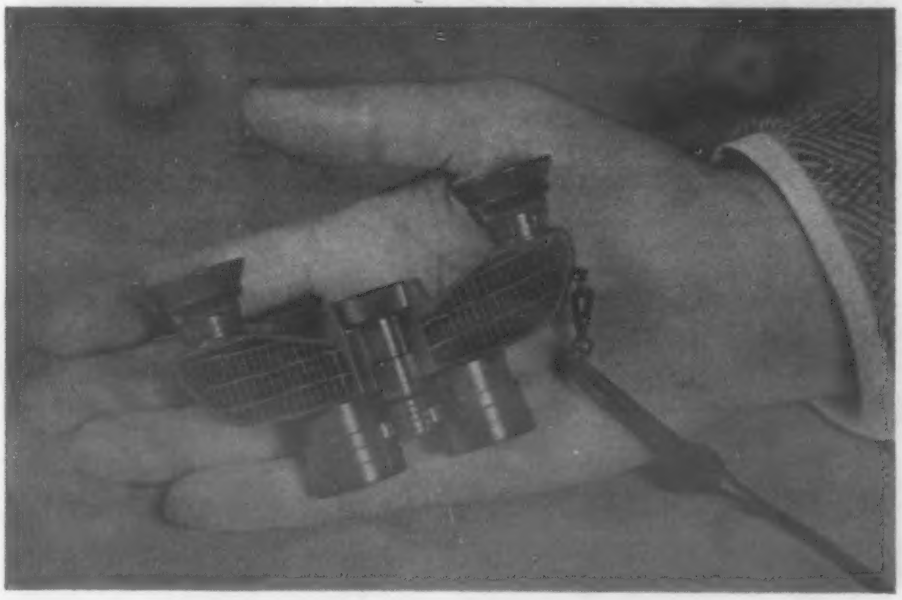
EMBOSSED ALUMINUM SHEET *Now available as a mill product is embossed aluminum sheet which is available with patterns such as squares, diamonds, stucco and simulated grained leather. The reasons for providing such patterns are manifold. Certain designs give directional rigidity, others add overall stiffening, and all result in an attractive finish which can often be used without further treatment. In the accompanying illustration the stucco pattern is used as the table of an ironing board. The stucco design provides a non-skid surface and the aluminum carries heat away swiftly. Reynolds Metals Co. produces the sheet in a variety of widths and in thickness from 0.010 in. to 0.040 in.*





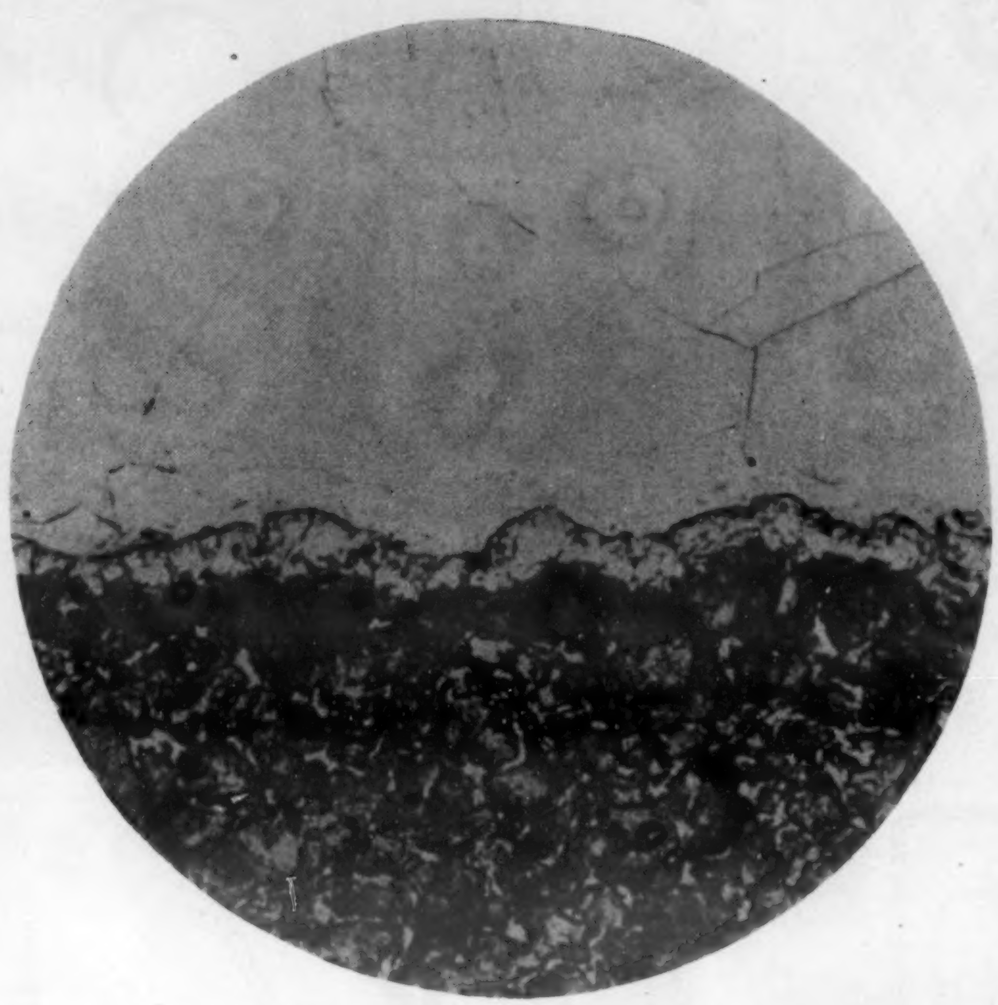
TRAILERAIL UNITS

Package shipments of goods which must be transported by both rail and highway are being speeded by a new development. Reynolds Metals Co. has produced aluminum "Trailerail" units which are transported to and from freight yards on specially designed truck trailers. When the shipment is to be loaded on the train, it is mechanically shifted from the trailer to a standard flat car. These units, already in use on one railroad, are said to eliminate considerable material handling—a saving to both shipper and carrier.



MAGNESIUM HOUSED BINOCULARS

A new sports binocular utilizes many advanced techniques and materials to achieve performance comparable with conventional binoculars weighing four times as much and three times as large. The tiny binoculars, which weigh only 4¼ oz., are housed in magnesium, which is cast to a complex shape by precision investment casting.



A permanent bond exists between the copper and steel, as this illustration shows, through the formation of a copper-iron alloy.

Copper-Covered Steel Proves Useful For a Variety of Applications

by HAROLD A. KNIGHT, News Editor, Materials & Methods

A material widely used in the electrical industry is now being selected for a variety of parts requiring strength and corrosion resistance.

COPPER-COVERED STEEL WIRE has been known and widely used by the electrical industry for many years. Since about 1915 it has been used where an electrical conductor was required to have strength higher than that associated with the high-conductivity copper. In such cases the composite wire, in which the copper covering provides the electrical properties and rust resistance and the steel core contributes the physical strength, was the material frequently chosen. It is available in two conductivity grades, namely, 30 and 40% of that of an equal cross-section of pure copper, and with a tensile strength approximately 2½ times that of copper.

Early applications included such items as long span power conductors, overhead ground wire, telephone wire and signal wire. At the same time, the electrical, railroad and communications industries recognized the value of the copper-covered steel wire for purposes where the copper covering provided corrosion resistance, and the steel core supplied strength, and it was used for guy wires, and for messenger wires—which support lead covered aerial power or telephone cables on overhead lines. The initial cost of the copper-covered wire was higher than that of galvanized steel wire, but the increased life and the savings in replacement costs more than offset this difference.

Recently the composite material is being used on a much broader basis, taking advantage of this combination of the high strength of the steel core and the excellent protection against corrosion afforded by the thick wall of copper surrounding it. Fasteners have utilized this combination of properties to obtain strong but rustless parts. Costume jewelry has been made with the composite. Miscellaneous manufac-

This lathe chip cut from a billet of copper-covered steel illustrates strength of the bond between the materials.

tured articles have found advantage in this combination of strength and freedom from rust. Finally, one of the larger uses has been in the architectural field, where resistance to weathering is a major factor.

Some of the specific applications in each field are:

(1) *Fasteners.* Slide fasteners have been made by coining from wire of the composite. The dies form the copper-covered wire without difficulty.

Nails and staples made of the material have the corrosion resistance of copper, but are superior to all-copper in strength. It might be expected that the steel core would be exposed by the heading and pointing operations but the softer copper seems to be smeared over the steel in such a way as to continue the protection at these points.

(2) *Costume jewelry.* When wire must be formed into delicate spirals, scroll and other intricate forms, the strength of steel is valuable. These items are usually plated, and a better plate is secured—whether it be chromium, silver, or gold—over a copper base. Use of the composite instead of starting with plain steel and copper plating insures that a coating of copper of satisfactory thickness will give the steel protection against corrosion and assist later plating even at points of contact in the design. The copper layer also facilitates soldering and several other fabricating operations.

(3) *Miscellaneous manufactured articles.* Lawn mower baskets undergo corrosive conditions as a usual service requirement. When made of copper-covered steel wire, the copper provides excellent resistance, while the steel gives the basket rigidity.

In flood control work along the Mississippi River, woven wire is used to give flexibility to the sectional concrete blankets used to reinforce dikes. Both strength requirements and resistance to corrosion must be high. The copper-covered steel is excellently suited for this application.

The New York Zoo installed wire fences of this material, thus eliminating and saving the cost of yearly painting. It has also been used successfully for barbed wire.

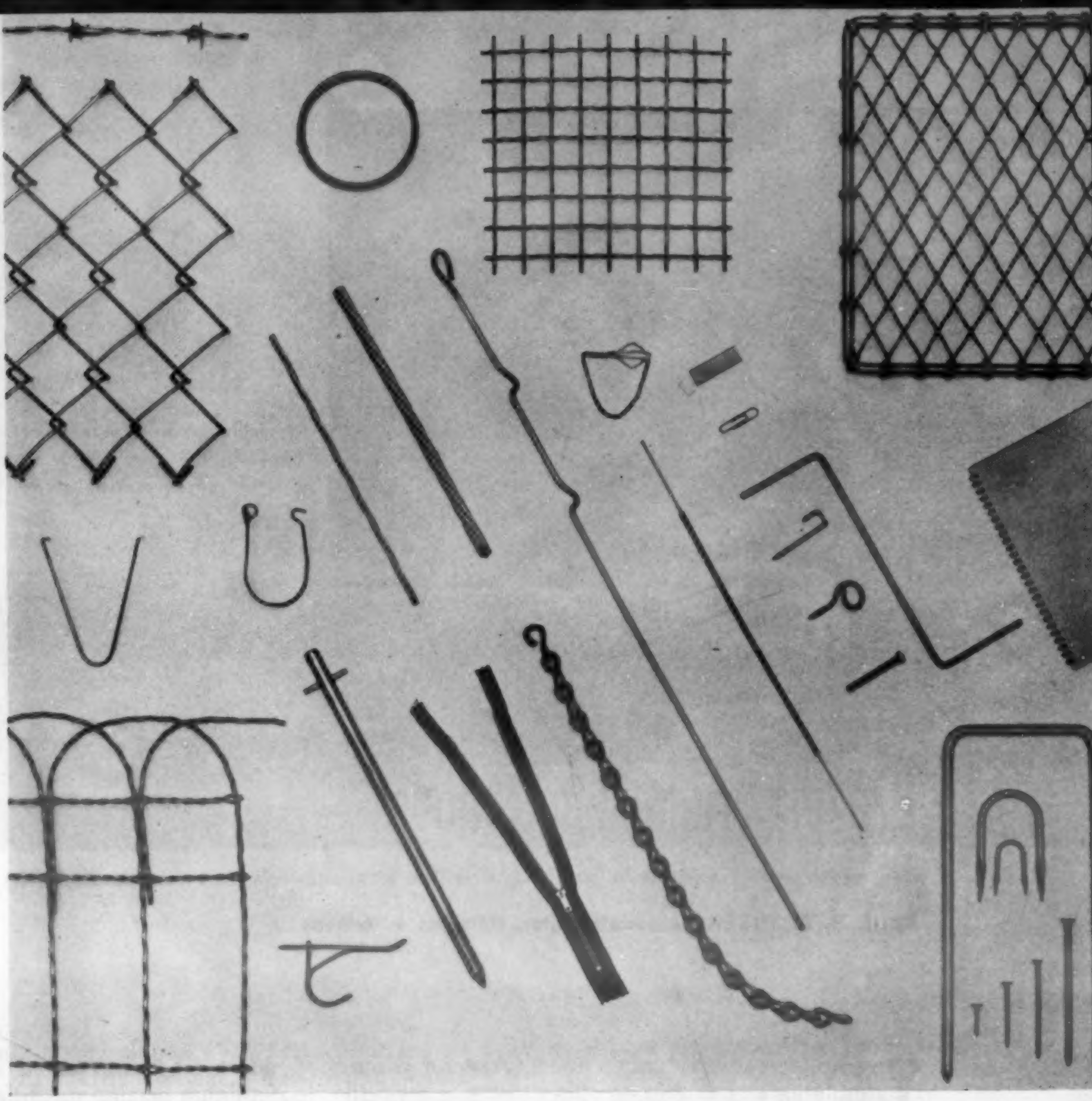
Military uses have been many, and have revolved about the combination of electrical conductivity, tensile strength and corrosion resistance.

(4) *Architectural uses.* In the erection of cavity walls of masonry, using either brick, tile or concrete blocks, tie rods are used to permit the inner and outer walls to give each other mutual support. These rods are subject to the corrosive action of the mortar and of the moisture in the air in the cavity. Inaccessible after the wall is built, the rods cannot be replaced during the life of the wall, and no inspection to determine the extent of corrosion, and of the corresponding loss of strength, is possible. Copper-covered steel wall ties have won wide acceptance because of their permanence.

Pipe hangers for the support of copper spout and flashing find in copper-covered steel an ideal material, strong enough to carry the load, and without the streaking of wall surfaces or sagging of the part that result from corrosion of plain steel hangers.

Copper-covered steel rod and wire is made by the molten-welding process developed by Copperweld Steel Company, Glassport, Pa., and used by them for more than 30 years. It begins with the making of ingots of the combined metals, and continues through the rolling down of these pieces into bars and rods, and the drawing of the rod to wire. Through all the processes for reduction of area of cross-section, the relative sizes of the steel and copper sections remain constant, and the final product has the same proportions of steel and copper as the original ingot.

The steel core of the composite ingot is of a special manganese forging quality. A billet of this steel, about 6 in. in dia. and 4 ft. long, is carefully centered



Here are many types of completed products using copper-covered steel wire. They include: barbed wire and fencing material; cable rings; slide fasteners; costume jewelry; nails; bookbinding wire; and many other uses.

in a graphite mold and the mold is then placed in a furnace and heated to proper temperature. Electrolytic copper is melted in gas-fired furnaces and poured into a ladle. The graphite molds containing the steel billets are then removed from the furnace, and the molten copper is poured into the mold around the white-hot steel core. A permanent molten-weld takes place at once.

After cooling, the ingot is removed from the mold, and reheated to rolling temperature. This temperature must be closely controlled so that the copper, with a melting point about 800 F lower than that of the steel, and the steel itself will be made sufficiently plastic to permit reduction of cross-section, but neither will be melted, nor made so plastic as to be reduced excessively. The ingots are rolled to bar stock, and then to rod. The rods are heat-treated and when wire is to be produced, the rod is cold-drawn to the desired size in wire-drawing machines.

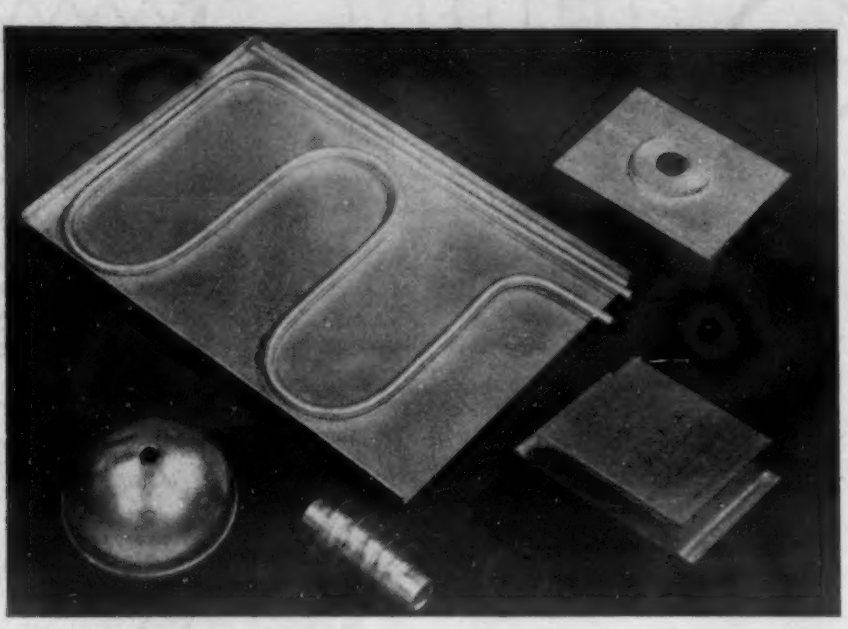
Because the original ingot is round, and the entire process has as one of its principal objects the reduction of the diameter without changing the cross-sectional proportions of the steel and copper, the material is available in round rod or wire only. Wire sizes run to 20-gage or finer.

As has been stated, the original applications of the copper-covered steel were electrical, and took advantage of its high strength combined with good conductivity and rust resistance. Tensile strengths vary depending upon the amount of cold working and in some wire sizes are of the order of 175,000 psi. Conductivity can be either 30 or 40% of equivalent diameter of copper. These electrical applications are too familiar to need detailing, but a few recent ones are interesting.

Erection of power transmission lines, especially in mountainous areas or across rivers have required the use of long spans of wire. Many of these spans have been installed using copper-covered steel conductors with span lengths ranging up to 6800 ft. The copper-covered steel wire has proved its worth on such installations.

Wire for railway signal systems must have not only good strength and good electrical conductivity, but sufficiently high resistance to withstand the corrosion resulting from the combination of moisture and combustion gases which may attack the wire. The composite wire has been a favorite here also.

The widespread use of copper-covered steel wire is another indication of the progress toward tailored materials—of materials combining the properties of two or more simple substances to form a new substance with properties different from either, and fulfilling some need of modern industry.



Typical aluminum brazed parts showing the type of joining that can be accomplished.

Brazing Aluminum Alloys

by H. R. CLAUSER, Associate Editor, Materials & Methods

THE ADVANTAGES OFFERED BY BRAZING for joining aluminum and aluminum alloys makes it a worthwhile process to consider when planning the fabrication of aluminum products. The cost of brazing is generally lower than the cost of either gas or arc welding. Brazed joints have a neater finish and therefore require less finishing. In addition, brazing is readily adaptable to production line methods. Finally, sections too thin for welding can be brazed successfully.

Aluminum brazing is still relatively young. Up until late in the thirties it was labeled as something that could not be done. But by 1940 development work had progressed far enough so that parts, such as outboard motor gas tanks, were being successfully brazed. Then during the war rapid progress was made and brazing found many war-time applications, particularly in the aircraft industry. A typical example of its use was for fabricating aluminum heat exchangers formerly made of copper.

Brazing of aluminum was unsuccessful for a long time for several reasons. For one thing, the tenacious oxide film present on the surface of pure aluminum and its alloys prevented the brazing alloy from wetting the aluminum surface and there was no practical means of reducing or readily dissolving it. Fluxes were finally developed that remove the oxides from both the base and filler metals and that also serve as a protective coating against further oxidation, and assist the free flow of molten filler metal.

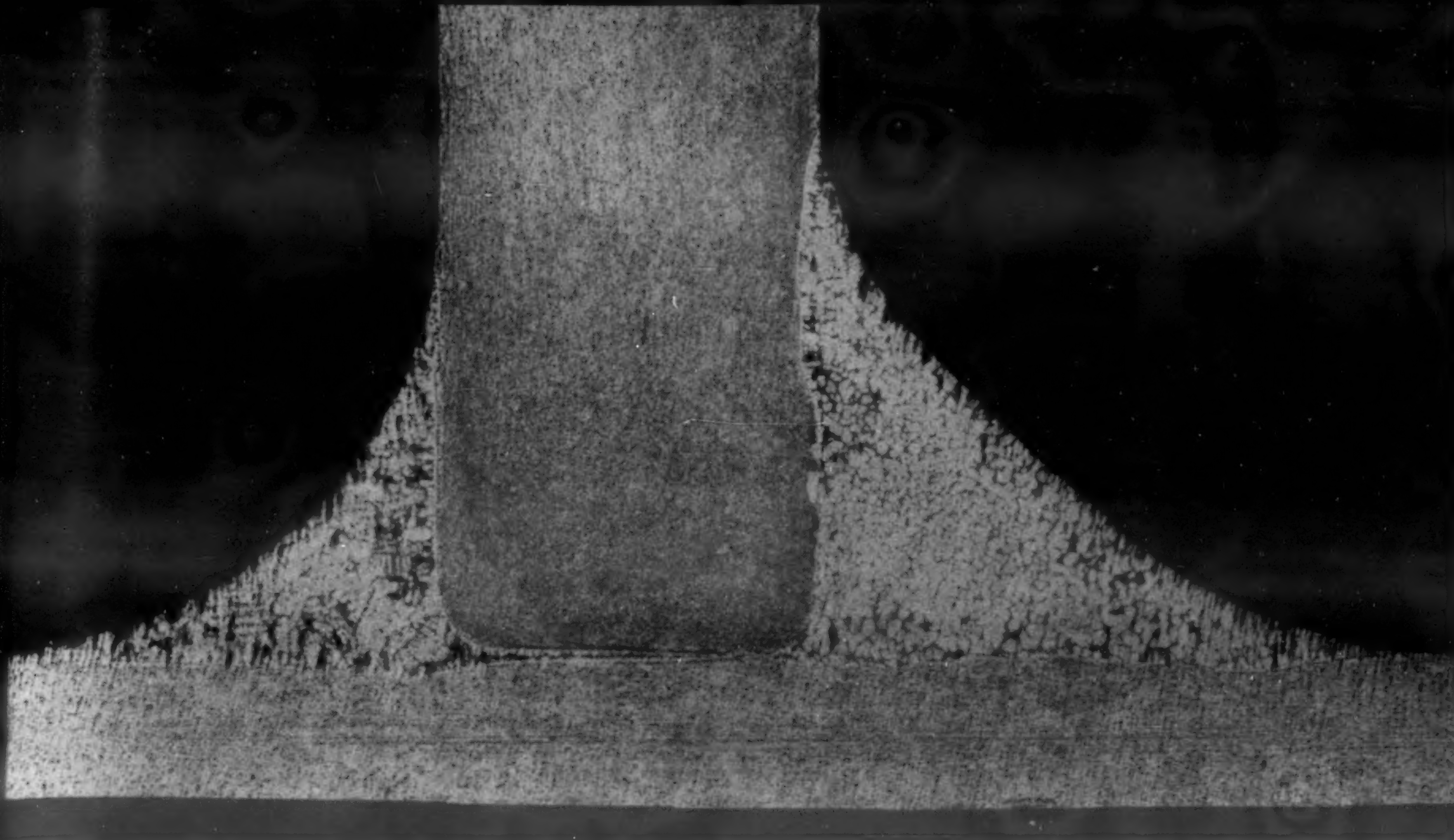
Another difficulty that had to be surmounted was the relatively small difference in melting point between brazing alloys and the base metal. In brazing other metals the differential between the brazing alloy and metal being brazed is at least 200 F. But in aluminum brazing the difference is only 100 F or less. Thus, it was necessary to work out accurate processing methods and careful temperature control before aluminum brazing could be made commercially feasible.

Finding suitable brazing alloys with a melting range lower than that of aluminum alloys was another problem. Aluminum-silicon alloys were the answer. They were first used in Europe with reasonable success; they were further developed in this country, and at present are the only brazing alloys suitable for aluminum.

In the progress of all this development work three different methods of brazing were worked out. They are furnace brazing, molten bath dip brazing, and gas torch brazing. All three are now being used in commercial practice.

At present four standard wrought alloys can be brazed commercially. They are commercially pure aluminum (2S), aluminum-manganese (3S), and

When making parts of aluminum, consider the use of brazing, which can be applied to several wrought alloys by most common brazing methods.



Microstructure of a typical brazed joint. Note that little or no melting occurs in the parent part. (Magnification 15X)

the aluminum-magnesium-silicon alloys (53S or R353, and 61S or R361). Any other wrought aluminum alloys of higher purity than type 2S can also be brazed. Two of the alloys, 2S and 3S, are nonheat-treatable and two, 53S or R353 and 61S or R361, can be heat treated. Since the brazing temperature is above the annealing temperature of all these alloys, brazing parts made of the nonheat-treatable alloys puts them in the annealed or soft temper condition. Parts made from the heat-treatable alloys are also annealed by brazing, but can be reheat-treated or in some cases quenched from the brazing operation to attain high strength.

Although procedures have been worked out for certain aluminum casting alloys, the brazing of castings is still in the development stage. The melting ranges of cast alloys are generally lower than those of the nonheat-treatable alloys, and so the filler materials developed to date cannot be used.

Brazing Alloys and Fluxes

As has been mentioned previously, the filler metals for brazing aluminum are basically aluminum-silicon alloys. For brazing the higher melting point alloys, 2S and 3S, the filler material usually used contains around 5% silicon; for the lower melting point alloys, the composition is about 10 silicon, 4% copper. The brazing alloys are available as wire, shims, rings, washers, etc. The form that is used depends upon the joint design of the parts being brazed.

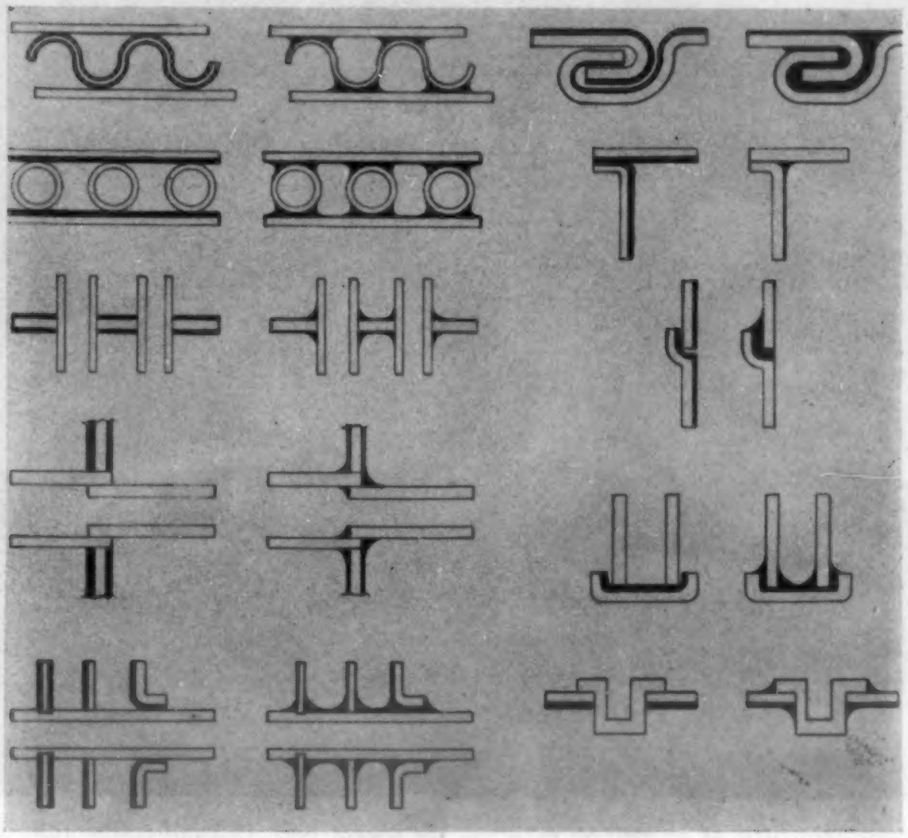
In addition to the above, a special aluminum "brazing sheet" has been developed. This sheet is produced by rolling a thin layer of brazing alloy on one or both sides of the base aluminum alloy. Products can be made from this material by any of the common forming methods and brazed without the addition of any other filler material. When parts assembled of this material are raised to the brazing temperature, the layer of brazing alloy melts and flows into the openings at the joints and seams. The advantages are obvious. No preplacement of brazing filler material is required and the problem of metal flow is largely taken care of, because the brazing alloy is already present on all joining surfaces.

The sheet is available from Aluminum Co. of America in three combinations of alloy and coating. The various types are listed below:

Designation	*Sides Coated*	*Coating Thickness*
No. 1	1 side	10% up to 0.020 in.
No. 2	2 sides	5% over 0.020 in.
No. 11	1 side	10% up to 0.063 in.
No. 12	2 sides	5% over 0.063 in.
No. 21	1 side	10% up to 0.093 in.
No. 22	2 sides	5% over 0.093 in.

Nos. 21 and 22 have a heat-treatable aluminum alloy core, while all the others have a core of 3S, which is nonheat-treatable. Therefore, if directly quenched after brazing or if given a subsequent heat treatment, Nos. 21 and 22 will give higher mechanical properties than the others.

The coating on Nos. 1 and 2 makes them most suitable for uses where a light-colored part is required. The coating on Nos. 11 and 12 and Nos. 21 and 22 have a lower melting range, for use where a lower brazing temperature is desirable.



Schematic drawings of various types of joints made with brazing sheet, before and after brazing.

Brazing sheet has wide application. It is particularly suited for furnace and dip brazing. It can also be torch brazed, but certain precautions must be taken. Brazing sheet can be used to particular advantage in assemblies where it is difficult to preplace filler metal in the form of shims or wire.

A number of different aluminum brazing fluxes are available to meet a wide range of requirements. The lowest melting point flux has been designated as No. 33 by the Aluminum Co. of America. It is used for brazing temperatures of 1100 F and below; it is the most chemically active, and gives maximum flow of filler metal. Nos. 30 and 53 were developed for brazing temperatures above 1100 F, and No. 34 for temperatures of 1090 F and above. No. 53 is only slightly chemically active, and No. 34 has no chemical action; therefore, these last two fluxes are most suitable for thin work. In addition to these, the Air Reduction Co. has developed a flux, designated "Elite," for torch brazing.

The flux comes as a dry powder and is usually mixed with distilled water to form a thick paste for application. It may be applied by brushing or spraying. If sprayed, the flux must be thinned further. A wetting agent is sometimes added to assure a uniform spread and thickness of flux on the metal.

Brazing Temperatures

Aluminum Alloy	Melting Range, Deg. F	Brazing Temperature Range, Deg. F
Pure Aluminum	1218	1160-1185
2S, 3S, Nos. 1 and 2 Brazing Sheet	1190-1215	1160-1185
53S or R353 and 61S or R361	1075-1205	1060-1090
Nos. 11 and 12 Brazing Sheet	1065-1090	1090-1140
Nos. 21 and 22 Brazing Sheet	1065-1090	1090-1120

Design and Properties of Brazed Joints

Proper joint design is as important for successful aluminum brazing as it is in brazing other metals. Since the flow of the filler material depends upon gravity and capillary action, tight fits must be avoided. The joint design should assure complete penetration of the filler metal. Clearances of 0.006 to 0.010 in. are usually satisfactory for laps less than ¼-in. long; for longer laps clearances up to 0.025 in. can be used. For best mechanical properties, lock seam, lap, fillet and tee type joints are preferable to the butt or scarf types.

Wherever possible parts should be designed to be as nearly self-jigging as possible, so that they can be easily positioned for brazing. This is often accomplished by using rivets or providing projections or flanges on one of the mating members. When jigging is required, the use of steel for fixtures should be avoided. The difference in thermal expansion between aluminum and steel is enough, in many cases, to pull the parts being brazed out of line. Aluminum alloy jigs can be used; care must be taken, however, to select an alloy that will not melt at or below the brazing temperature; and the design must be such that the brazing alloy will not touch the jig. Also, because of the high heat conductivity of aluminum,

Batch brazing of aluminum outboard motor gasoline tanks, in an electric furnace. Aluminum brazing sheet was used in this application.

there should be a minimum of contact between the jig and the assembly.

There are two other design considerations that are important in aluminum brazing. In brazing closed assemblies care must be taken to provide for the escape of gases during the brazing process; otherwise, ignition of the gas formed by action of the flux on the metal may cause an explosion of sufficient force to push the assembly out of line. And, finally, the design of the assembly must allow for complete cleaning of the joint after brazing. This is necessary since flux residues will cause corrosion of the metal if not properly removed.

The strength of aluminum brazed joints is about the same as that of gas-welded joints. Of course, the strength depends upon a number of factors, including the type of aluminum being brazed, the joint design, and heat treatment, if any, after brazing. For example, brazed joints in 3S aluminum alloy, which is nonheat-treatable, have good ductility and tensile strengths around 14,000 psi. On the other hand, the joints in some heat-treatable alloys attain a strength of around 24,000 psi. by solution heat treatment. And, if precipitation heat-treatment follows this, the strength can be raised to over 35,000 psi.

Not much definite data is available on the corrosion resistance of the brazed joints. However, salt spray and exposure tests have indicated the corrosion resistance of brazed joints to be about the same as that of welded joints in the same alloy. Also, since the brazing alloys are aluminum-base alloys, similar to the base metal, electrolytic corrosion, caused by differences in electrolytic potentional between different metals, is considerably reduced.

In general, the appearance of aluminum brazed joints correctly made is smooth and regular and neater than that possible by welding. The joints require little or no finishing. In color the brazed joint closely matches that of the aluminum alloy base metal. Where a lighter color is desired, brazing sheet Nos. 1 and 2 can be used.

Aluminum Brazing Methods

Furnace Brazing—As mentioned earlier, aluminum brazing can be done by furnace, dip, or torch methods. Furnace brazing consists of fluxing the areas to be brazed as well as the filler material either before or after assembly, then placing the parts in a furnace and heating them above the melting point of the brazing alloy, but below that of the base metal.

Furnace equipment is similar to that used for brazing other metals. The chief requirement is that control of temperature be within ±5 F; this requirement makes automatic temperature control almost mandatory. Gas fired or electric, batch or continuous type furnaces capable of a temperature range of 1000 to 1200 F are all suitable. No special atmosphere is used; the normal furnace atmosphere should be circulated to reduce heating time and provide a more uniform temperature throughout the furnace. When gas fired furnaces are used the products of combustion should not come in contact with the parts.

Parts with section thicknesses in the range of 0.008 to 0.50 in. can be furnace brazed. Thicknesses less than 0.008 cannot generally be brazed satisfactorily, because the moisture in the flux attacks the aluminum, often causing perforations in thin sections. Assemblies are sometimes preheated at around 400 F for 10 or 20 min. to remove the excess moisture. Large flat areas should be avoided in designs for furnace brazing to minimize the possibility of sagging.

The time required for brazing a part depends upon the thickness and size of the part. Very thin sections, around 0.008 in., will reach brazing temperature in a matter of minutes, while a ½-in. thick part takes 40 to 45 min. to reach temperature. Two to 6 min. at the melting temperature is required for the brazing alloy to flow into the joint. Wide ranges of thickness in parts should be avoided in assemblies that are furnace brazed, because of the large difference in rate of temperature rise.

Furnace brazing is being used widely as a produc-

tion method for brazing a variety of aluminum parts. One example is the torque converter for buses being furnace brazed by the White Motor Co. The part was formerly made of sand castings; however, rejects were high and the part was on the borderline for strength. The brazed design has reduced rejects and lowered cost, while increasing the strength of the part.

Another example is the supercharger intercooler made by Harrison Radiator Div. of General Motors. In vibration tests, intercoolers of soldered copper construction failed after 27 min. on the vibrating machine as compared to over 50 hr. with brazed aluminum construction. Other typical furnace brazed parts are tube and fin radiators, tube and sheet assemblies, refrigerator trays, small tanks, and carburetor floats.

Dip Brazing—In dip brazing a molten bath of brazing flux is the heating medium. As in furnace brazing, the parts are assembled with the brazing alloy in position. However, no fluxing is required since the assembled parts are heated right in the molten flux. The parts are held in the flux bath until the brazing alloy melts and flows into the joints. In some applications where increased speed and smoother joints are desired, the parts are preheated to 900 to 1000 F before placing them in the bath.

Racks for holding parts in the bath are usually either nickel or pure aluminum wire. Although cast iron, stainless steel, and nickel alloy racks have been used, contamination of the bath by these materials may result.

Either No. 53 or No. 54 flux is used for the heating flux bath. External gas-fired or electric resistance salt bath furnace equipment is satisfactory as long as the temperature control is within ± 5 F. Proper selection of the pot material is important to avoid contamination of the flux. Pure nickel pots are widely used and also certain ceramic linings. There are other sources of bath contamination that must be guarded against. Additions of flux to the bath or a fresh batch of flux when melted is a source of water which attacks the aluminum parts unless the bath is dehydrated. This is done by dipping aluminum sheet into the flux.

Dip brazing is not an economical method for small, intermittent production work. It is most efficient for continuous production brazing. For, if the furnace is shut down, the flux becomes a solid mass and not only is time lost in bringing it back up to operating temperature, but also extensive time and labor is required to repurify the bath.

Parts with section thicknesses in the range of 0.008 to 0.50 in. are generally considered suitable to dip brazing. If the flux bath is correctly dehydrated, it is possible to dip braze pieces as thin as 0.006 in. Although large thickness variations should be avoided, dip brazing allows larger variations than does furnace brazing. The brazing cycle is shorter than in the furnace method. Depending on the thickness and mass of the part, brazing can be accomplished in from ½ to 3 min. Since the entire assembly is immersed in flux only, parts that permit complete drainage of the molten flux after brazing or that can be flushed clean are suitable to dip brazing.

Dip brazing is comparatively new, but has already been used for such products as finned tubing, radiators, heat exchangers, switch boxes, and aircraft duct sections. One of the first applications was the brazing of air heaters for the flying fortress by McQuay, Inc. In this unit the problem of fabricating a large number of pressure tight seams and joints was solved by dip brazing. Another application was heat exchangers for portable oxygen generators. They were made up of four brazed parts and withstood pressures of 165 psi. and higher.

Torch Brazing—In torch brazing a gas welding torch supplies the heat which melts the brazing alloy at the joints. The filler material can be used in wire form and fed into the joint or it may be preplaced in the joints in the form of washers, rings, or disks. In torch brazing the flame is not directed on the filler material; it is played on the base metal which, in turn, melts the brazing alloy when the brazing temperature is reached.

Oxyacetylene, oxyhydrogen and various oxynatural gas flames are suitable heat sources. The first two flames produce a smoother, cleaner joint and are faster than oxynatural gas flames. A neutral or slightly reducing flame must be used and this is most easily maintained with an oxyacetylene gas combination. Also, oxyacetylene produces the hottest flame. The advantages of using the highest temperature flame are: the metal can be raised to the brazing temperature quickly, resulting in faster brazing and less gas consumption; and the heat can be concentrated where it is needed, thus minimizing the tendency to distort and buckle.

Torch brazing can be mechanized by using multi-flame burners and conveyor systems. In such applications the filler metal is preplaced and the heat is controlled by the number, position, or size of the flames and by the speed of the conveyor.

Whereas dip and furnace brazing are usually limited to section thicknesses of ½ in. and under, torch brazing is suitable for parts with thickness greater than this. There is no definite maximum thickness, but 1½ in. is probably the thickest section that can be practically brazed. Heavier sections than this are more easily welded. Torch brazing cannot handle sections as thin as those possible in furnace or dip brazing. The minimum thickness is around 0.025 and 0.030 in.

Parts having large thickness variations can be torch brazed. In one particular case a nipple with a wall thickness of around ½ in. was brazed to a 1-in. sheet. This method is also applicable to designs that have large mass or that are intricate in form and could not be jigged properly for furnace or dip brazing.

Torch brazing has been widely used in the aircraft industry and in the manufacture of aluminum furniture. Cooking utensils is another large application; also, refrigeration equipment, builders' hardware, and electronic and electrical equipment.

As has been indicated, each of the methods discussed above has its advantages and limitations. The final selection of which one to use should depend upon a careful analysis in relation to the product that is to be brazed, because how successful and economical aluminum brazing can be depends to a great extent on this choice of the brazing method.

Improving the Adhesion of Organic Finishes Over Zinc Plate

Enamel over zinc-coated steel failed to hold after several heat shock tests on this housing, although the same finish adhered to the dichromate treated magnesium body.

by **ROLAND E. KOHL, Works Laboratory, General Electric Co.**

EQUIPMENT ON AIRCRAFT must withstand extreme conditions. By no means the least of these is the sudden change in temperatures from those at ground level to those at high altitudes, or the reverse change, from low to high temperatures on descending.

One effect of such sudden temperature changes is loss of adhesion of organic finish films applied on metal surfaces. Such trouble has been experienced with the finish on motors, amplidynes, etc., installed on military aircraft.

Zinc has served long as a corrosion prevention medium for steel. Its ability in protecting exposed steel areas, such as scratches and sheared edges, is well known.

Somewhat less familiar, possibly, is its failure, at times, to provide an adequate "tooth" for or a good bond with organic finishing materials.

Nevertheless, a lot of zinc coated material or work (hot dip galvanized or electro-zinc plated) is finished with organic finishing materials without any surface preparation other than removal of oil, grease and dirt. The adhesion of such organic films to zinc may be adequate for many purposes, provided the service conditions are not severe.

The accompanying illustration shows what happened to the wrinkle enamel finish on an amplidyne when this piece of equipment was subjected to several cycles of "heat shock" test that included 16 hr., 100% relative humidity at 40 C (104 F); 4 hr. at -40 C; and 4 hr. at 135 C (275 F).

A simple method has been found to make finishes hold on plated steel parts even though the parts serve through wide temperature ranges.

It will be seen that the wrinkle enamel is intact on the body of the amplidyne. This is a magnesium casting, dichromate treated (Dow #7 treatment), sprayed with zinc chromate primer, baked, and sprayed with wrinkle enamel and baked.

The end covers, where the finish has lifted, were made of steel and electro-zinc plated. After plating they were sprayed with zinc chromate primer, baked, and then sprayed with wrinkle enamel and baked.

Obviously, the adhesion of this wrinkle enamel had to be improved. Various surface treatments for zinc were evaluated for their effectiveness in providing a "tooth," for subsequently applied organic finish films, which would be good enough to maintain satisfactory adhesion during 25 cycles of the heat-shock test described above. (This was a government requirement.)

A commercially available chromate solution, containing formic acid, used as a dip immediately after zinc plating, was found to produce the best surface on electroplated zinc for our purposes.

Organic coatings applied over electro-zinc plated surfaces so treated maintained good adhesion throughout the required 25 cycles of heat, cold and humidity. This dip treatment was, therefore, adopted and has been used for the past several years, with very good success, on all zinc plated parts requiring organic finishing.

The same treatment prevents the formation of white zinc salts in the 100-hr. 20% salt spray test as required by paragraph C-2d of Army-Navy Aeronautical Specification AN-P-32-a for zinc plate. The process works equally well on cadmium-plated parts and meets Specification AN-P-61, Amendment 2, Paragraph C-2c.

The use of Knoop hardness numbers offers a new approach for plastic testing. Here shown is a Knoop Indentation in cellulose acetate sheet (125x).

How to Make and Interpret Hardness Tests on Plastics

by **VINCENT E. LYSAGHT**, Wilson Mechanical Instrument Co., Inc.

PLASTICS ARE BEING ADOPTED more and more for such industrial products as bearings, gears, and elements of construction, and, therefore, the need for accurately determining their hardness is becoming increasingly important. Hardness tests—more specifically, indentation hardness tests—have a number of valuable uses. They can be used to indicate the machining, punching, buffing characteristics and sometimes the mechanical wear resistance of plastics. Also, compressive and possibly tensile moduli can be approximately indicated from hardness values. With some thermoplastics, hardness can be related to resistance to softening with increase in temperature. Finally, hardness tests can serve as a routine check in controlling manufacturing processes and also as a quick non-destructive identification test.

Indentation hardness tests for plastics include Rockwell and Rockwell Superficial methods, Brinell method, 136-deg. diamond pyramid test, Knoop and scleroscope tests. In these tests, with the exception of the scleroscope, equilibrium may not be reached upon applying and removing the load in the usual manner. In some cases, due to size of load, shape of penetrator and resistance to the plastic to indentation, the penetrator would continue to indent the material indefinitely. Therefore, to obtain reproducible results, it is essential that the exact time the load is applied to the material be specified. Also, since the indentation hardness of plastics may vary to a considerable extent with temperature and humidity, all samples should be properly conditioned. For example, the ASTM method D-618 calls for a temperature of 77± 1.8F and 50% relative humidity.

This article is based on a chapter from Mr. Lysaght's forthcoming book on hardness testing, to be published by Reinhold Publishing Corp.

Rockwell Test Methods

The Rockwell hardness tester is the most widely used instrument for measuring the hardness of plastics. Most of the tests are carried out following the procedure of the ASTM (designation D 785).

It should be pointed out here that the Rockwell hardness tester was designed for testing metals where the amount of recovery of the metal, upon removal

Indentation hardness tests can provide much valuable information about processing and application characteristics of plastics. Here all the test methods are brought together and compared for the first time.

of the major load, is small in proportion to the total depth of penetration. With plastics, on the other hand, the amount of recovery of the material is large in proportion to the total indentation. Thus, with plastics having elastomeric characteristics, the results of the Rockwell Test, taken in the usual manner, may not be of any value since the recovery is so great in proportion to the total indentation. Methods for obtaining indentation index on the Rockwell tester, with the major load applied, are described later.

In making a Rockwell test in the conventional manner, there is a certain amount of spring in the frame as the major load is applied. This may be observed on the dial gage, and since it is an upward movement of the frame, with respect to the plunger rod holding the penetrator, it registers on the dial gage in the same direction as penetration into the material being tested. After the major load is removed, the spring of the frame, caused by the major load, is recovered. This factor, therefore, does not enter into the reading, because the gage dial is set at zero before the application of the major load and the final reading is taken upon removal of the major load.

For metals, excluding shapes such as tubes, the movement of the dial gage due to the elasticity of the metal under test is small and may be considered no disadvantage when making the test. With plastics this elasticity may reach considerable proportions, and when acting in addition to the spring of the frame of the tester, may prevent full application of the major load due to limitations in the design of the tester.

It is a safe assumption to consider the limitation of the standard model Rockwell tester as 150 dial gage divisions under a load of 150 kg. This figure represents the number of divisions of travel of the dial gage due to penetration into the material under test, spring of the frame, penetrator and plunger rod system, and elasticity of the material under test, while major load is applied. Special Rockwell testers, designated as PL models, increase this limitation to 250 divisions under load of 150 kg.

To determine whether the machine limitation is being exceeded and whether the major load is being fully applied, the major load is applied in the usual manner. With the major load still acting, an additional load is applied by hand pressure on the weights on the machine; the dial gage needle then should indicate additional penetration. If not, the full major load may not be acting (due to reaching limit of depth of indentation) and faulty readings may result.

In testing for hardness, most plastics are time-sensitive. In the Rockwell method, the time factor must be considered at three different stages of the test. First, after the minor load is applied, there may be creeping of the needle of the dial gage when testing soft plastics. If the major load is applied *immediately* after the dial gage is set at zero, it is not necessary to apply a time factor to the minor load. It is desirable, however, to specify some time—for example, 10 sec.—as the interval within which the minor load is applied and the zero setting is made.

Second, the time of application of the major load must be controlled carefully if reproducible results are to be obtained. The results of many tests on plastics of different hardness indicate that a 15-sec. loading time is satisfactory. This time interval starts when the major load is applied (lever tripped) and ends when the load is removed. It includes, therefore, the time for applying the load, as determined by dash pot control valve setting, as well as the time during which the full load is applied and creep occurs. A shorter time interval than 15 sec. may result in the removal of the major load while the dial gage needle is moving quite rapidly; a longer time interval lengthens the time required to make the test and increases the time for cold flow unnecessarily for some plastics. If the loading time of 15 sec. is maintained, reproducible results may be readily obtained. It is obvious that when creep occurs there is no single time interval which necessarily results in a "true" Rockwell hardness number, and the 15-sec. interval has been agreed upon as a compromise to effect economy of time and reproducibility.

The third time factor to be considered is the interval after removing the major load at which the Rockwell number is observed. Here again 15 sec. has been found to be satisfactory. There has been a tendency to stretch this time factor to 45 sec., but this delays the time required to make the test, without any appreciable gain. This factor is not as sensitive as the time factor for applying the major load.

Many variations of the above time cycle will be found in industrial testing of plastics. Appreciable differences will result if readings are taken with other sets of time factors and compared with tests as outlined above. However, if the time factors specified are used, then good correlation will result, provided the full major load is applied to the specimen.

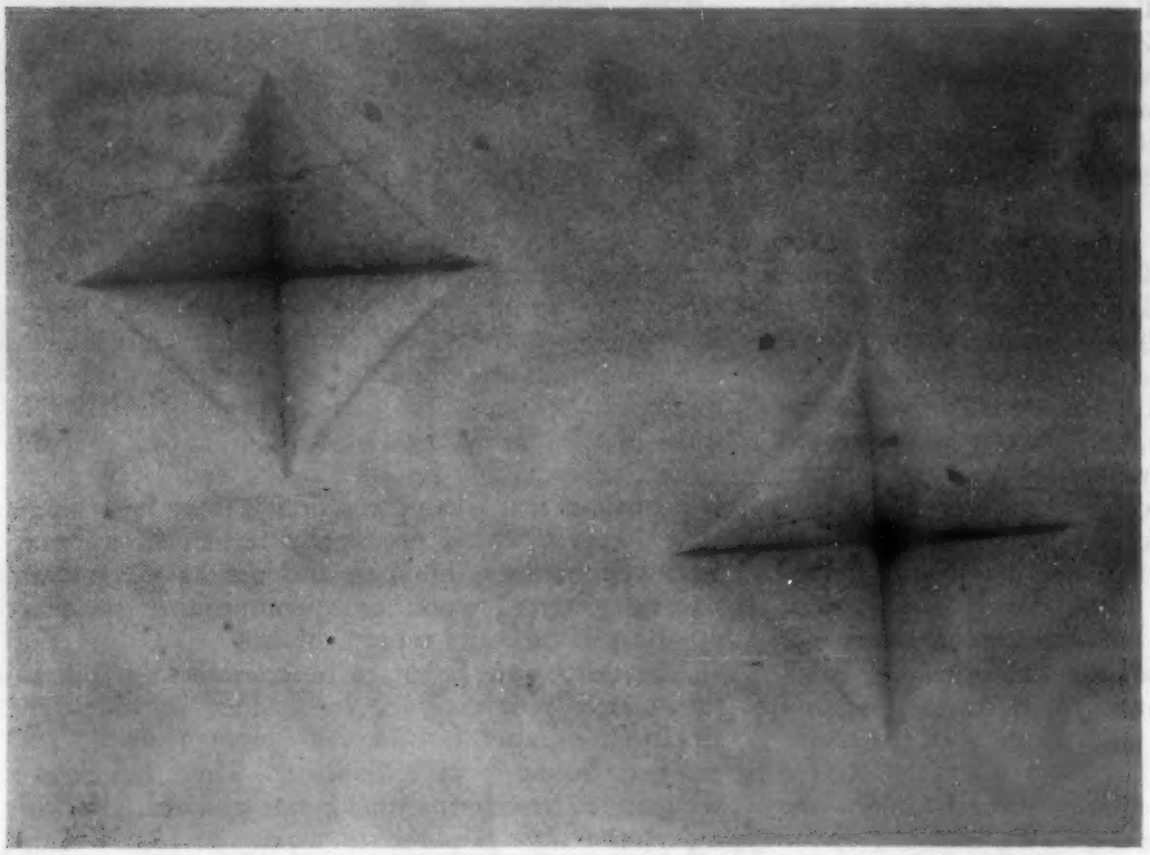
The penetrators generally used for testing plastics are the ⅛-, ¼- and ½-in. dia. balls and the loads are the 60 and 100 kg. The scales are the E, L, M and R. While some slight advantage might be gained by use of the P and S scales, the scales first mentioned will take care of plastics very nicely from inorganic filled melamine to soft cellulose acetates. Table I shows the load and penetrator for each of the scales.

In selecting the proper scale, the limiting range of the machine (150 divisions of penetration for normal and 250 divisions for PL model) should not be exceeded. If it is exceeded, a lighter load or larger ball penetrator should be used.

Readings over 100 are generally not recommended because of lack of sensitivity with such high values. However, in the interest of continuity, and to keep

Table I—Scales: Normal Model Rockwell Tester

Scale Symbol	Penetrator	Load in Kilograms	Dial Figures
E	⅛-in. ball	60	Red
L	¼-in. ball	60	Red
M	¼-in. ball	100	Red
P	¼-in. ball	150	Red
R	½-in. ball	60	Red
S	½-in. ball	100	Red
V	½-in. ball	150	Red



Pyramidal indentation on vinyl chloride acetate. Measurement is difficult because impression changes due to slow creeping recovery of the indentation.

the number of scales to a minimum, values up to 115 may be permissible.

Following the above precautions, reproducible results to better than ± 1 Rockwell number should be obtained. Seldom (except in the case of laminates) is it necessary to make more than 3 to 5 determinations to obtain a good average.

The specimen thickness should be ¼ in. unless it has been ascertained that thinner samples are not influenced by the supporting anvil. It has been found satisfactory to test more than one piece of a plastic to meet the thickness requirement, provided the samples are free from burrs and other protrusions. If more than one piece is used, this should be noted in the results.

The material should be supported on a flat anvil. A spot anvil should not be used as it might act as a penetrator. The samples must be flat so as to properly seat on the anvil. Specimens should be 1 by 1 in., if possible, and never less than ½ by ½ in.

Alpha and Beta Scale Tests—In a very complete study of the testing for hardness of plastics by indentation methods, using the Rockwell tester, L. Boor has developed a procedure which permits measurement of indentation depth under the major load. Boor proposes the use of two scales, the alpha and beta. Reduced to fundamentals, it consists of first determining the spring of the tester for the particular machine and penetrator being used, and then applying minor and major loads to the specimen.

The alpha scale uses the ½-in. ball penetrator and 60-kg. load. The test is made by applying the minor load in the usual manner, setting the dial at zero or "set," and applying the major load (60 kg.) for 15 sec. With the major load still applied, the number of divisions the penetrator has traveled from zero or "set" is read on the dial gage. From this figure the spring of the tester is subtracted (determined under major load of 60 kg.) and then the remainder is subtracted from 150.

The beta test is performed in exactly the same manner, except the major load is 30 kg. and the spring of the tester is determined under the major load of 30 kg. As this load is special, the value of the weight applying it may be determined as follows. It is necessary to make a special weight pan. For the machines having a weight pan weighing 2490 gm., a weight pan weighing 990 gm. must be substituted to apply 30 kg. Those machines having a weight pan weighing 1849 gm., a pan weighing 649 gm. must be used to apply 30 kg.

The alpha and beta scales provide a simple indentation hardness test covering the entire range of plastics, based on the unrecovered depth of indentation. This test eliminates residual indentation, such as obtained in the usual Rockwell test, and as the values obtained do not bear any relation to values of indentation obtained upon recovery after removal of major load, there may be some merit to results obtained by this method.

Recovery After Indentation Method—In practice there is a method being used which combines the features of both the standard methods and the alpha and beta method just described. Many users of the Rockwell hardness tester, and even users of the Rockwell superficial hardness tester, have found that information secured from recovery of indentation after removal of the major load, in addition to the Rockwell number determined in the regular manner, is very helpful in determining machining problems and controlling the quality of their plastic products. This information has been reported as useful, provided

the composition and processing of the material were held to the same specifications.

In using this method a load and penetrator are selected which will give good sensitivity consistent with the flow and creep of the material. This requirement will determine whether the normal Rockwell hardness tester or the Rockwell superficial tester is to be used. In general, the heaviest load and smallest penetrator which do not give too much creep or produce an impression which does not show through on the reverse side of the sample underneath the test, are selected.

The spring of the tester is determined. A time factor is used for the length of time for applying the major load after the release is tripped and, if necessary, before reading the hardness value after the major load is removed. The minor load is applied and indicator is placed at "set." The major load is then applied for a definite time interval, the dial reading being recorded with the major load still applied. The major load is removed and the dial reading again recorded. If a second time factor is necessary, the reading is observed after this selected time has elapsed.

The two readings are then plotted on a vertical line graph. The lowest reading or deepest penetration—that is, the reading taken with the major load applied—is then corrected for the spring in the tester.

As more than one revolution of the dial will occur when testing plastic material, it is recommended that three revolutions, or 300 divisions of the dial gage, be used as the scale. It is advisable to record all readings on the basis of these three revolutions, making certain that the readings are in the proper revolution of the dial and proper position of the 300 division scale. If in the machine being used three revolutions are not available, then two revolutions may be used provided the full load is applied to the specimen.

An accompanying graph shows a sample of two materials, A and B, which may show the same value when major load is applied, but which have a decidedly different value after major load is removed. It is possible that the material having the high recovery has certain advantages in some applications, whereas in other applications material with low recovery is desired.

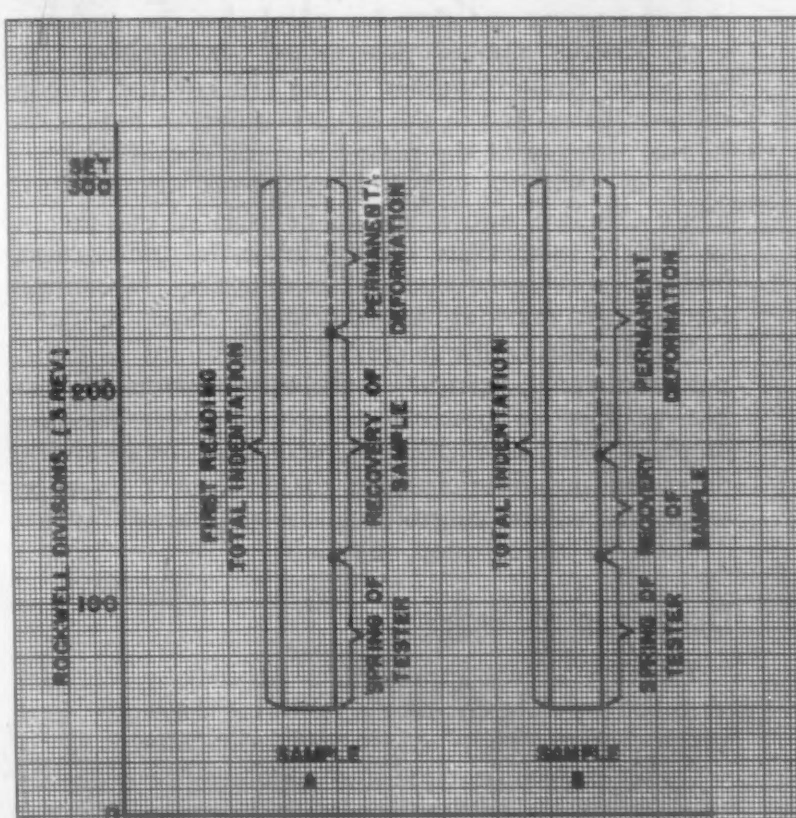
Rockwell Superficial Tester—The Rockwell superficial tester can be used for testing plastics and may offer some advantage over the normal model because of the lighter loads employed. However, there are many more normal model testers in use. Some of the advantages gained by use of light loads are offset by a more sensitive depth measuring system. Basically, the superficial model Rockwell tester is for testing thin material—not soft material—and the fact that thin sheet plastic materials may be stacked in making hardness tests has tended to promote the use of the normal model.

Other Methods

Brinell Method—The Brinell test for plastics generally uses loads of 500 kg., and a 10-mm. dia. steel ball, applying the load for 30 sec. Sometimes the baby Brinell test (12.6-kg. and 1/16-in. ball penetrator) is used. The specimen for the standard Brinell test should be at least 0.125 in. thick. The application of the test is limited. The edge of the indentation is often poorly defined, and ridging of the impression sometimes occurs. Most important, however, is that in most plastics, recovery takes place after removal of the load, making the measurement of the diameter of indentation inaccurate. This recovery is rapid for the first few seconds and slow creeping recovery continues for sometime afterward.

Scleroscope Method—As elastic properties of plastics are often of considerable importance, it would seem that the scleroscope might be used for measuring the hardness of this type of material. However, it is used only to a very limited extent and then only when resiliency as well as hardness is concerned. This is probably due to the fact that hardness readings for some plastics on the scleroscope may be higher than those obtained on mild steel, whereas indentation tests, such as the 136-deg. diamond pyramid test, Rockwell method and Brinell, show the plastics to be considerably softer.

136-deg. Diamond Pyramid Test—In testing plastics with the 136-deg. diamond pyramid method, using either the Vickers or Tukon tester, the load used is generally 5 kg. In this test, the length of time for applying the load is an important factor. With the Vickers tester, the full load is usually applied for 10 sec. With the Tukon tester, the time of application is automatically controlled in the instrument. The impression will recover to some extent upon removal of the testing load. Since the measured diagonals likewise recover somewhat, the 136-deg. diamond pyramid test is in the same class as the Brinell, in



In the Rockwell method recovery after indentation is an important consideration. Chart shows two materials having same hardness value under the major load, but different values after major load is removed.

Table II—Approximate Hardness Values of Typical Plastic Materials

Material	Knoop Hardness Number 200 Gram Load	Rockwell Alpha Scale	E Scale ⅛-100	M Scale ¼-100	L Scale ¼-60	R Scale ½-60	Bierbaum Scratch Hardness 3 Gram Load	Scleroscope
Bakelite BM 261	53	128	82	109	—	—	21	80
Bakelite BM 120	42	122	88	114	—	—	19	85
Polystrene (inj)	17	109	—	76	—	—	10	70
Polystrene (comp)	17	106	—	79	—	—	10	75
Plexiglas II	16	102	—	97	111	—	17	80
Plexiglas I A	16	100	—	88	106	—	17	80
Fibestos	12	65	—	49	82	—	10	70
Ethyl Cellulose (Med)	6	43	—	—	47	95	6	55
Saran (inj)	4	12	—	—	20	78	9	40

that the measurement of the impression will change due to slow creeping recovery of the indentation.

Knoop Hardness Number Method—The Knoop indenter and Tukon tester offer a new approach to the problem of testing plastics. While the long diagonal is affected to some extent by elastic recovery, nevertheless it is affected to a far less extent than the short diagonal or even the diagonals in the 136-deg. diamond pyramid test. The hardness number is, therefore, less dependent on recovery.

Furthermore, the time of load application is automatically controlled in the design of the tester. Very light loads may be used which means that this particular indentation hardness test may bear some relation to the scratch test, especially with indentations made with loads of 25 to 100 gm.

In routine testing, loads from 100 to 1000 gm. may be used. It is possible to measure the width of the impression and then by calculation the unrecovered Knoop number determined. By relating the recovered Knoop number to the unrecovered Knoop number, calculated in the usual manner, an indication of the recovery of the plastic may be obtained.

At this writing very little has been accomplished along this line, and it should be pointed out that it is difficult to measure the width of the indentation, and an experienced operator is necessary. In routine testing only the long diagonal is measured.

For measuring the length of indentations in transparent material, vertical illumination and the highest N. A. objective possible is recommended. The use of phase contrast microscopy, which is now receiving the attention of microscope manufacturers, may be advantageous in determining the length of the indention in transparent materials.

Comparison of Methods

Table II shows approximate hardness values determined by different hardness testing methods. This table covers typical plastic materials in different hardness ranges, from phenolics to acetates. The materials are listed in the hardness order as determined by the Knoop indenter and Tukon tester under load of 200 gm.

It will be observed that there is agreement between this order and the order as determined by the alpha scale of the Rockwell tester. However, the M scale of the Rockwell tester shows a difference in order of hardness, which is probably due to recovery of the specimen upon removal of the major load. It should be remembered that the long diagonal of the Knoop indentation is but little affected by elastic recovery.

By including values for the E, M, L and R scales of the Rockwell tester, an idea of the sensitivity and overlapping of the scales may be obtained. It must be kept in mind that the amount of recovery will vary not only with the elasticity of material, but also with the amount of major load.

Bierbaum scratch hardness values are included to show the order of materials in resistance to scratch and to emphasize that resistance to permanent indentation differs from scratch resistance. As can be seen from the table, even resistance to permanent indentation is restricted to the actual conditions of any one test.

As mentioned previously, resistance to scratch or even mar resistance might be determined by the Tukon tester and Knoop indenter using a 25-gm. load and producing an indentation only a few microns deep. If successful, this would permit substitution of the more rapid indentation hardness measurement for the scratch resistance measurement and eliminate such difficulties as judging the precise location of the edge of the scratch under a microscope. More work must be done along this line to see if microhardness is of value.

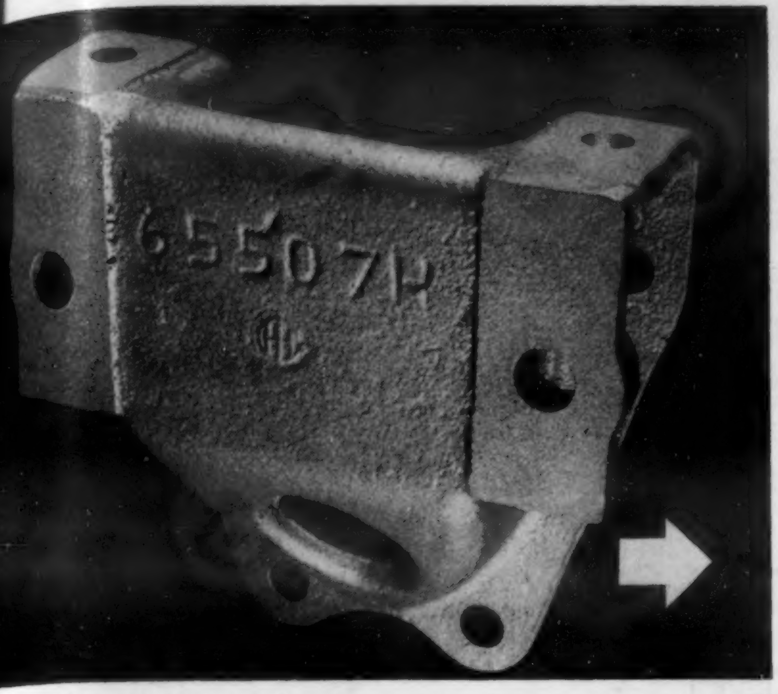
References

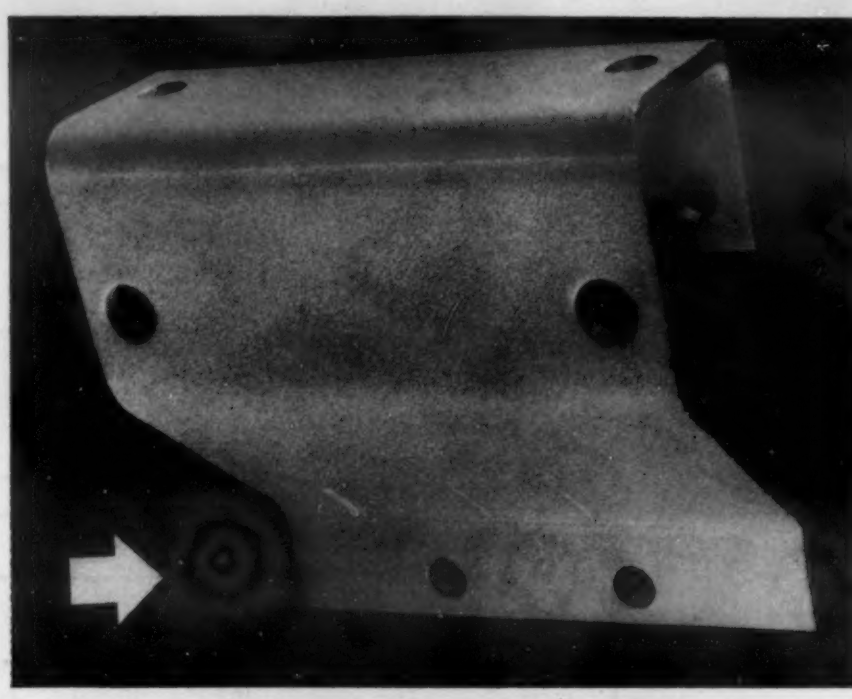
"The Knoop Indenter as Applied to Testing Non-Metallic Materials Ranging From Plastics to Diamonds," V. E. Lysaght, *A.S.T.M. Bulletin*, No. 138, January 1946.

"Indentation Hardness of Plastics," L. Boor, Proceedings, *American Society for Testing Materials*, Volume 44.

"The Measured Knoop Hardness of Hard Substances and Factors Affecting Its Determination," N. W. Thibault & H. L. Nyguist, Norton Co., Worcester, Mass. Annual Convention of the *American Society for Metals*, Atlantic City, N. J., November, 1946.

"Metals in Thin Layers, Their Microhardness," Chauncy G. Peters & Frederick Knoop, *Metals and Alloys*, September 1940.





inally the frame bracket for engine support was a malleable iron casting (left). Now the part is made as a stamping (right), with a considerable saving each year.

How Conversion to Other Materials Solved Malleable Castings Shortage

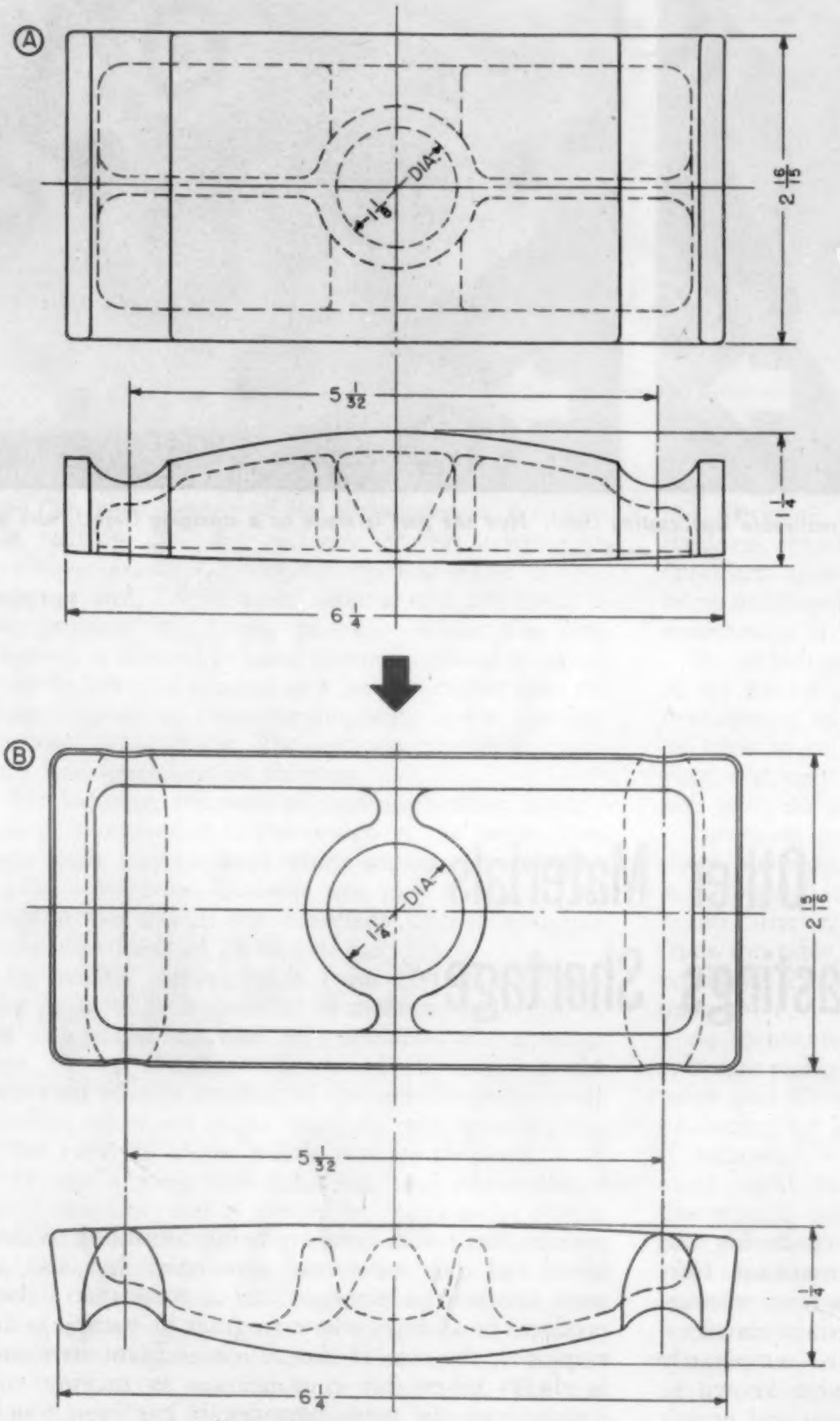
by HERBERT CHASE

SHORTAGES OF MALLEABLE CASTINGS during and following the war led the International Harvester Co. to convert many parts from castings to some other fabricated form. In certain instances, malleable castings were even converted temporarily to steel castings, even though costs were known to be higher, so as to avoid certain shortages and permit deliveries of much-needed farm and other equipment. But many other malleable castings were replaced by forgings or by stampings or by a combination of both.

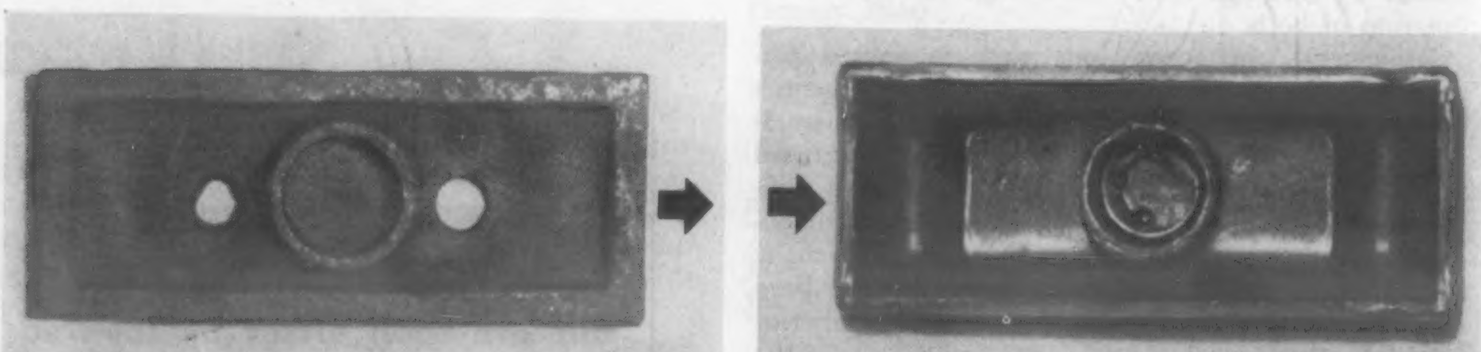
In general, the conversions were motivated primarily to reduce the backlogs that the company's malleable foundries could not handle, but this situation has since been relieved by acquiring increased malleable foundry capacity so that some parts converted have reverted to the malleable cast form because of greater economy in production. In many cases, however, the forgings or stampings have been retained either because greater economy or a superior product or both result.

Most of the conversions from malleable castings to forgings or stampings that applied to truck components, dealt with here, are being continued, as they afford not only substantial economies, but also, in most instances, a stronger and a somewhat lighter product. In all cases where forgings or stampings are employed, the cost of dies is a significant item and is always given due consideration in making cost comparisons. In most instances, it has been found, however, that die costs are fully amortized through savings within a year or less and that often there are

International Harvester truck components are converted to forgings or to stampings with savings in cost and weight. Tooling costs generally are higher but are soon offset by lowered piece costs.



In this illustration A is a malleable iron seat for a rear spring clip, while B is a forged seat for the same application. Although die costs were high the forged product is less expensive.



The malleable casting (left) was replaced by a two-piece stamping (right) joined by resistance welding at a substantial saving.

savings in machine work on the piece and sometimes in jigs or fixtures needed for machining castings when used in place of the wrought product.

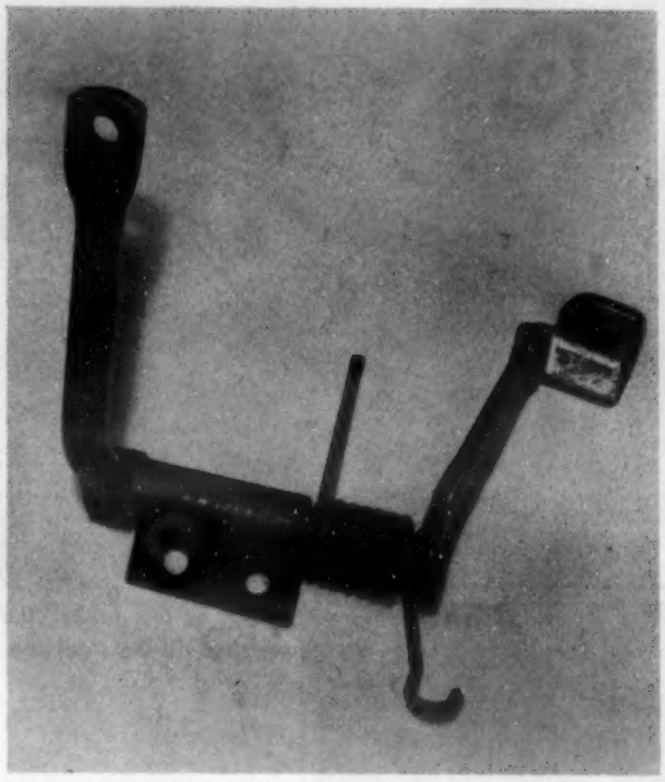
It is better not to generalize beyond a certain point in making comparisons, partly because so many factors have a bearing on the over-all results. But it is profitable for engineers and production men to study specific cases in which comparisons in actual production have been made. It is unlikely that any particular example will be found to be paralleled exactly by requirements in some other field, but a study of any example is likely to suggest expedients that may fit a particular case or at least make a close analysis along this line worth while.

In cases here cited, forgings and stampings usually have proved less costly and better in other respects than malleable castings, but this is not a reflection upon such castings as a whole. There are many cases, of course, where parts that could be forged or stamped are cheaper and entirely satisfactory when produced alternatively as malleable castings. Each case in point deserves analysis on its merits and it is seldom possible to say in advance which is the better alternative until each factor affecting the results has been weighed.

In one case, malleable iron frame brackets, two of which support the rear engine bearers in certain models of truck, have been replaced by simple steel stampings. The cost saving per piece is about 60%, but this applies to quantities some eight times larger than for the casting. This saving amounts to about $31,000 a year, but required an investment of $2,200 in tooling. Thus, the investment is amortized by about one month's savings realized by stamping. Foundry demands were reduced by about 70 tons a year.

There is some saving in weight and also a marked saving in machine work. With the stamping, no machining is necessary other than that done in the press; holes are pierced in the blanking operation. With the casting, six bolt holes had to be drilled and some bosses required facing. Although the casting presumably is much stiffer than the stamping, because of the ribs used, the stamping is entirely satisfactory and has ample strength.

In producing a rear spring clip seat, malleable iron formerly was used to the tune of about 36 tons a year. When the part was converted to a forging,

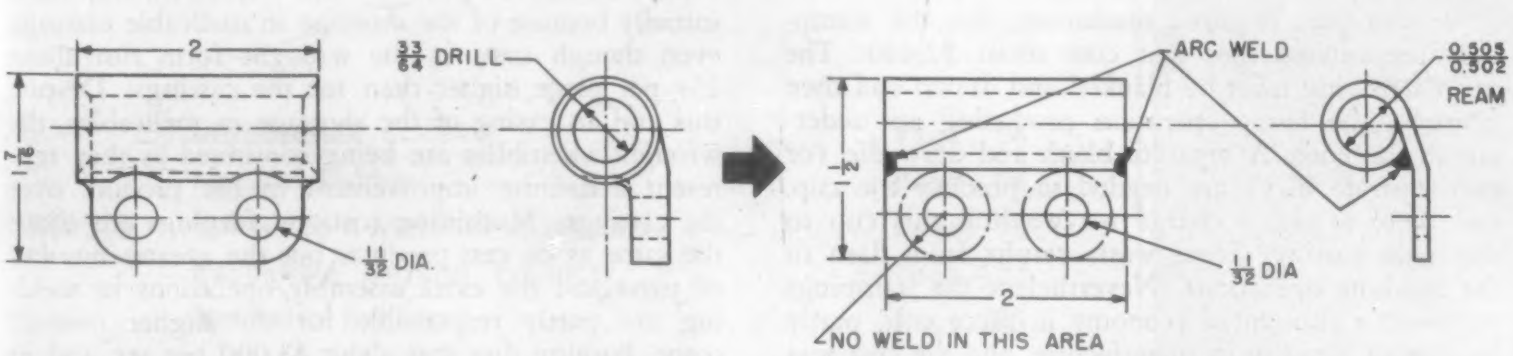


Here are combined in a starter control assembly a stamped lever and a malleable iron bracket. Formerly, the lever also was a malleable casting.

a saving of about $4,500 a year resulted and a stronger part was secured, although both types have sufficient strength. In this case, no machining is required on either piece, as the parts are fastened by U-bolts that fit grooves near the ends. The chief advantage comes from the higher rate at which forgings, as opposed to castings, are produced. In other words, labor charges are reduced, the forging being made, substantially ready for use, in two rapid operations: forging and trimming.

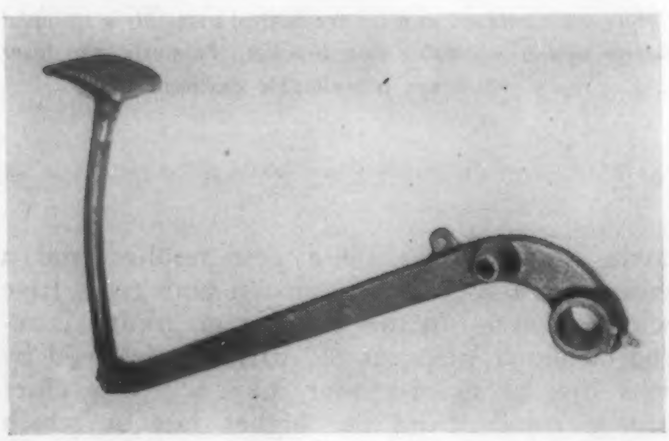
There is, however, a substantial investment in forging dies and their maintenance, but these are more than offset by lower piece costs in the quantities required. It is also an advantage to have the parts made in the truck plant rather than by an outside foundry.

For a similar but lighter rear spring clip seat,



Designs were simplified for such parts as this starter shaft bracket when changed from malleable iron to rolled and welded steel.

An advantage in stamping such parts as this brake cam bracket is that the holes can be punched during stamping.



Two forgings are welded to a round bar to produce this brake pedal. The cost of this part is greater than if it had been produced as a malleable casting. However, quality is considered sufficiently improved to offset the added cost.

somewhat similar conditions apply in respect to the malleable casting. But when this part was converted to a stamping, costs per piece dropped about 50% and saving of some $6,000 a year resulted. Side holes cored in the casting are not needed in the stamping but it requires a separate cup spot welded at the center to provide an equivalent of the circular recess cored at the center of the casting.

Neither part required machining, but the stampings necessitated dies that cost about $2,440. The main stamping must be blanked and drawn and then restruck, the latter operation producing an undercut at the ends. A separate blank and draw die (or two separate dies) are needed to produce the cup, and there is also a charge for welding this cup to the main casting. Some waste results from flash in the blanking operations. Nevertheless, the stampings represent a substantial economy in piece cost, partly because of rapidity in manufacture, and die cost was amortized out of savings realized in producing about five month's requirements.

Malleable iron was used for a starter control lever. This part required a hole, for a mating shaft, which had to be drilled, reamed and chamfered and a hole for a cross pin fastening which required drilling. This lever is now stamped. Initially, the stamping also was drilled for a cross pin but it is now projection welded to the end of a new shaft, and this saves drilling both hub and shaft for a pin and providing and inserting the pin. Production of the stamping reduced cost over casting about 20% or $344 a year. It involved, however, tooling costs of $474, hence it required more than a year to amortize tools.

Another bracket of malleable iron for the shaft required a hole to be drilled, chamfered and reamed and needed drilling and spot facing of flange holes. Now, the bracket is stamped, from steel, the eye being rolled, arc welded at the ends and then reamed. Flange holes are pierced in the blanking operation. The stamped bracket costs about 60% less than its cast counterpart and saves about $17,000 a year. The first year's saving was somewhat reduced by tooling costs of $3,000.

Another part that formerly was made as a malleable casting is a brake cam bracket now being made as a stamping from ¼-in. sheet stock. All holes in the casting had to be drilled, and spot facing was necessary on bosses at some holes. In the stamping, all holes are pierced in the blanking operation. Forming is done quite simply. Both types of parts require the insertion of a shoulder pin that is riveted in place but, in the stamping, a washer, produced separately, takes the place of the pin boss which is an integral part of the casting. Ribs on the casting probably make it stiffer than the stamping, which is somewhat lighter in weight, but the stamping is stronger and has adequate stiffness.

Stampings cost about 22% less than the casting but involve a tooling cost of about $1,110. Requirements are such, however, that the savings per year amount to $24,064, which amortizes tools in a short time.

Brake pedals and clutch pedals, which are similar in general design, now consist of a forged lever, having a hub, and a forged foot pad joined by a length of ⅝-in. round rod butt welded at each end to the respective forgings and then bent to an arc. Formerly, these pedals were produced as one-piece malleable castings having shapes similar to those of the wrought products.

Malleable castings were awkward to produce in this shape and did not have the strength that the welded assemblies provide. The conversion was made initially because of the shortage in malleable castings, even though costs in the wrought form run about 25¢ per piece higher than for the castings. Despite this and an easing of the shortage in malleables, the wrought assemblies are being continued as they represent a definite improvement in the product over the castings. Machining costs on forgings are about the same as on cast products but the greater number of parts and the extra assembly operations in welding are partly responsible for the higher over-all costs. Forging dies cost about $3,000 per set, and in this case are not amortized out of savings, since there are none.

...TERIALS & METHODS MANUAL

This is another in a series of Manuals on engineering materials and their processing published as special sections in Materials & Methods. Each manual is complete in itself and is intended to serve as a reference book on the subject covered. These manuals provide the reader with useful data on characteristics of materials or fabricated parts, and on their processing and application. Preceding manuals have taken their places in the permanent reference files of thousands of readers.

37

...bber as an Engineering Material

by Kenneth Rose, Engineering Editor, MATERIALS & METHODS

Rubber, unlike steel and metallic materials, is not specified or applied as a standard formulation. Rather, rubber compositions are devised to attain the desired properties for the applications in which they are to be used. Therefore, it is important that materials engineers know what properties can be provided in rubber—both natural and synthetic. This manual tells of the basic properties of rubber and how these properties can be changed through various additions and changes in processing. In addition, the author discusses the place of rubber in today's industrial scheme of things.

Contents

May 1948

Materials & Methods

Introduction

One of the first articles peculiar to the New World to be introduced to the Old was an odd dried gum with such a high degree of resiliency that it would rebound amazingly if thrown against a hard object. Columbus saw the American Indians playing games with a heavy black ball of this gum, and carried several of the balls back to Spain after his second voyage to Santo Domingo. They were exhibited at the court of Isabella as another example of the wonders of the new land.

The substance received as much attention as a new toy might be given, and no more. It was not a very prepossessing material. It was sticky, unmanageable, and so unlike any of the then used materials that its possibilities for practical application seemed to be nil. It bounced, and that was about all that could be said for it.

For 270 years the material was ignored. Finally, the English chemist Priestley discovered another novel property of the curious dried sap—it could rub out a pencil mark. From this it received the designation *rubber*.

It was another 20 years before the first real use of rubber as a material became a reality. The Scotch chemist Macintosh found that by using it as an interlayer between two pieces of cloth its stickiness could be overcome, and even utilized. His name became synonymous with the rainwear he produced in this manner. It was extremely poor rainwear by modern standards, for it became sticky in hot weather and stiff in cold, but it was a start in making use of the material from America.

The bouncing gum was the dried sap of any of a number of tropical plants. It was collected by the natives in the Amazon Valley and elsewhere, but was little more than a novelty to them. It does seem to have been used to some extent in producing a kind of waterproof cape or cloak, and this may have suggested the first practical use of the gum in Europe. Natives collected the sap from the trees, allowed it to coagulate by long contact with the air, and treated it over a fire, or else poured the latex over a stick held over a smoky fire, causing a ball of crude rubber to accumulate on the stick.

Several other crude attempts were made to use the gum, but it remained practically what it was when Columbus had brought the first bouncing balls to Europe from his voyages of discovery. It was not until 1839, almost 350 years after its introduction to civilization, that the history of rubber as an industrial material began. In that year Charles Goodyear devised the process of vulcanization, in which the rubber is heated with sulfur. The stickiness disappears, strength is increased, and the rubber can be hardened to an inflexible state, if desired.

Even with the devising of the process of vulcanization, the magic key that opened the doors of industry to rubber, the material was not taken up on a large scale for another 60 years. Rubber was obtained from Brazil, and was collected by wandering natives from trees growing wild in the forests. Many different types of plants contain a rubbery constituent in the sap, but this wild rubber was nonuniform in composition and properties. It was frequently adulterated by the collectors. Furthermore, the process of collecting was uneconomical, as months of wandering in the forests might be required for the accumulation of a few hundred pounds of crude rubber. The process supplied the demand only because the demand was quite small. Even as late as 1900 the United States imported only 27,000 tons of crude rubber.

Although the laws of Brazil forbade the exportation of seeds of the rubber tree, some were surreptitiously taken to London in 1876, and plantings were begun a few years later in Ceylon. Plantations were established in Malaya and the Dutch East Indies, and the tropical regions of the Far East a few decades later had become the rubber-producing center of the world. Other plantations were established in Africa, and finally Brazil, which had become almost a negligible factor in world production, encouraged the establishment of plantations.

Plantation rubber, obtained from a pure stand of Hevea brasiliensis, was a cleaner, more uniform product than the wild rubber collected in the forest and coagulated by makeshift methods. The only deviation from the use of plantation rubber from stands of Hevea came during the war years, when whatever wild rubber was available found a ready market. Plantings of trees and shrubs other than Hevea were also made.

While rubber as an industrial material had achieved recognition several decades before the turn of the century, its large-scale use coincided with the rise of the automobile industry in the United States. Use of rubber rose from 27,000 tons in 1900 to 766,000 tons of crude rubber in 1941, the last year of prewar production. Roughly 80% of this natural rubber went into the manufacture of tires and tubes.

With the outbreak of the war the enormous role of rubber in modern civilization was made painfully apparent. Loss of most of the plantation areas to the Japanese made the large-scale production of synthetic rubber and rubber substitutes a matter of utmost urgency. Fortunately, American industry was ready with the necessary know-how. The rubber companies had been doing research with the rubber molecule for many years, and the great chemical companies had had some success in the development of synthetics. These, and the results of European production in subsidized war industries, enabled the government to build plants capable of producing a sufficient amount of synthetic rubber, and to have them operated by rubber company technicians.

It must be pointed out at once that the term "synthetic rubber" is inaccurate. Experiments by the rubber companies for production of a true synthetic rubber—a compound made by man that would be chemically and physically identical with natural rubber—had failed. What had been produced by the chemical companies and by the rubber industry were elastomers, some bearing a general resemblance chemically to natural rubber, others quite different, but with physical properties resembling rubber to some degree. These man-made materials were inferior to rubber for most of the large-scale uses of that material, but possessed some points of superiority, particularly in heat- or oil-resistance. The first to become commercially successful, chloroprene, won a place for itself in industry during the early days of the 1930's, in spite of its higher price and the abundance of natural rubber. It is certain that all of the synthetics now in production will remain in production, as specialties at least, for the forseeable future.

The term synthetic rubber has won acceptance, and will be used here with the understanding noted above. An attempt is being made to gain currency for the designation "American rubber" for the synthetics, but that term has not yet come into general use.

In addition to the synthetic rubbers, another group of elastomers deserves passing mention. These are certain flexible plastics, such as vinyl polymers, in which flexibility is obtained or increased by incorporating a "plasticizer," usually a liquid, in the material. They have flexibility as one of their few points of resemblance to natural rubber or to the recognized synthetic rubbers, but are quite different chemically, and will not be mentioned with the synthetic rubbers here.

What are the general properties of rubber that make it so useful to modern in-

Density of Rubber

(Vulcanized Rubber—About 23 Cu. In. per Lb.)

	Density, Lb. per Cu. In.	Specific Gravity
Original latex	0.0353	0.98
Conc. latex	0.0350	0.97
Plantation rubber	0.0335	0.93
Soft rubber and sulfur, vulcanized	0.0342-0.036	0.95-1.00
Tread stock	0.041	1.13
Sponge rubber	0.004-0.025	
X-ray sheet (compounded with lead)	0.18	5.0
Hard rubber	0.04-0.07	1.13-2.00

Energy Absorption (Weight and Table)
(Indicates Capacity to Store Resilient Energy, in Ft.-Lb. per Cu. In.)

Gray cast iron	0.37
Extra soft steel	3.07
Tempered spring steel	95.30
Rolled aluminum	7.56
Phosphor bronze	4.08
Hickory wood	122.50
Vulcanized rubber	14,600.

Hardness Ranges

	Plastometer, ⅛-in. Ball	Durometer A
Hard rubber compounds	0 to 10 points	60 to 100 points
Soft rubber compounds	10 to 285 points	30 to 95 points

Natural and Synthetic Rubbers

	Specific Gravity	Hardness, Durometer A (100 is Bone Hard)
Natural rubber	0.93	20 to 100
Butadiene-styrene	0.94	35 to 100
Butadiene-acrylonitrile	1.00	20 to 100
Chlorobutadiene	1.23	20 to 90
Isobutylene poly.	0.92	15 to 90
Polysulfide types	1.34	35 to 80

dustry? Here they are:

(1)—*Stretchability.* Rubber is not very "elastic" as the engineer thinks of elasticity. It is stretchable to an astonishing degree, but it does not return to exactly the same dimensions as before stretching. This stretchability, or extensibility, is the most generally recognized property of rubber, in spite of the fact that hard vulcanized rubbers are almost completely devoid of it. Before rubber took its place among the industrial materials, leather or fabrics filled some of the places into which it subsequently went. Both would have been quite unsuitable for automobile tires, in which rubber first won a high-tonnage market. The place of the synthetics, now required by law in tire formulations, in a free market is still in dispute.

(2)—*Electrical insulation.* It is fortunate that the discovery of methods to utilize rubber antedated the extensive use of electrical machinery, for it is difficult to see what substitutes for rubber in wire covering could have been found among the materials then available. Electrical insulation has always been an important use for the natural product, and today the same field is taking a sizable part of the production of some of the synthetic rubbers also. For special applications, as in motors to operate at temperatures above the usual permissible figures, the synthetics have an advantage.

(3)—*Flexibility,* or *resilience.* Related to stretchability is the property of withstanding flexion. The idea of resilience is also connected with these properties. Rubber possesses all to a high degree, and they make it a preferred material for such items as gaskets, printing rolls, upholstery, and hose.

(4)—*Water resistance.* The first application of rubber to practical use took advantage of its ability to form a thin, flexible, continuous film that was impervious to water. This property today gives it many of its important uses, such as in rainwear, fire hose, and flexible tubing. Here again rubber is facing a challenge from some of the new plastics, such as the vinyls and polystyrenes, and it must share with them a field it once held almost exclusively.

(5)—*Chemical resistance.* Because of its high resistance to many chemicals, rubber has always been an important material in the laboratory and chemical plant for stoppers, gaskets, tubing, and similar articles. A weakness of natural rubber in this respect was its poor resistance to petroleum oils and many solvent hydrocarbons. As several of the synthetic rubbers have good resistance to petroleum products, they have widened the usefulness of the rubber group, so that oil hose is now made of synthetic rubber.

(6)—*Bonding properties.* The original stickiness that prevented rubber from being more than an interesting curiosity for more than three centuries has become one of its important industrial properties when properly controlled. Rubber forms the basis for most of the adhesives bonding to metal. Adhesives for other uses, especially if flexibility is required in the finished article, are also frequently made with rubber. The bonding of fabrics and leather, as in the cloth-backing and shoemaking industries, uses rubber-base adhesives widely.

Many of the above properties are difficult to evaluate, and some are not even well understood. A result is that rubber articles are seldom bought to composition specifications. Three large organizations, the United States Government, the Fire Underwriters, and the American Association of Railroads, still have both composition and performance specifications for rubber, but aside from these, rubber is bought almost entirely on a basis of performance.

This state of affairs results from the universal practice in the rubber industry of compounding. Rubber is practically never used as a simple vegetable product. Vulcanization is widely used, and there is a considerable choice of vulcanizing agents and accelerators, with the properties of the finished article and the processing characteristics affected by the choice. In fact, the final properties are affected by so many ingredients and conditions of processing that any attempt by the purchaser to specify formulations would defeat the object of the specifications—to obtain a rubber item that will give good service under a given set of conditions.

The rubber industry is one of the few in which the customer asks the manufacturer to supply a part that will meet specific service conditions, and specifications are confined to dimensions, color, and perhaps performance characteristics or tests indicating them. This gives the manufacturer a free hand to turn out an article that will meet those requirements.

This being the case, it follows that there are no series of standard rubber compositions from which the user can make a selection to meet his own needs. Rubber as supplied to the industrial user is a custom material, tailor-made to fill a given set of requirements. The information given here is not a guide to formulating, but a general listing of the principal types of materials going into a manufactured rubber, and a brief mention of the role each plays in the formula.

Natural Rubber

When the bark of the rubber tree is deeply cut with a series of V-shaped grooves, a milky sap exudes and can be collected. This milky sap is natural latex, and consists of a suspension of rubber globules in a watery serum. Crude rubber is made from it by:

(1)—Coagulation, and mechanical treatment of the curd
- (a) by washing and drying if for pale crepe rubber
- (b) by drying and smoking for smoked rubber

(2)—Drying by evaporation, to produce sprayed latex rubber or powdered rubber.

The natural latex also finds its way into commerce as such, with the addition of preservatives.

Following are the types of rubber leaving the plantation to go into industry:

(1)—Ribbed smoked sheet (6 grades)
(2)—Pale crepe
- (a) thick (3 grades)
- (b) thin (3 grades)

(3)—Natural latex
- (a) cream
- (b) centrifuged
- (c) normal

(4)—Guayule
(5)—Fine Para (4 grades)
(6)—Blankets (4 grades)
(7)—Browns (4 grades)
(8)—Flat bark crepe

The plantation stages in the production of rubber are mentioned not only for their general interest, but because rubber at every stage in the process from latex on finds application as such in industry; that is, latex rubber as such is supplied to certain industries, notably the adhesives industry, as a material, and is used without further refinement.

Most of the latex is converted into crude rubber at the plantation, however, and the crude is shipped to the manufacturer for use as such, or, for the most part, to the rubber processor for further refinement.

Milling or Mastication

Rubber is naturally elastic, and therefore difficult to work. The first process is intended to make it more workable. This is done by kneading in machines in which the rubber is forced to pass between two rolls, turning upon each other but at different speeds, so that the rubber is subjected to both compression and shearing. The rubber worker refers to this process of making the crude material softer and more plastic as "killing the nerve." When first fed into the rolls the crude rubber twists, cracks, and snaps, but as the milling proceeds it becomes readily workable.

The degree of plasticity developed in the material is related to Mooney viscosity, the viscosity falling rapidly as the milling takes effect. A curve showing plasticity-time of milling is given as Fig. 1. Heat, moisture, and other factors influence the plasticity of the rubber, so that the curve shown is not necessarily typical.

The milling process affords an opportunity to incorporate other ingredients into the rubber mass, and it is at this time that the other types of rubbers, curing agents, etc., are usually added.

Compounding

As has been said, rubber is seldom used as a simple, pure vegetable material. Compounding, or formulating, is the practice of mixing together definite ingredients in certain proportions so that, when the whole is vulcanized, the finished product will have the properties desired. In addition to the rubber itself, which may be of some or all of several kinds, the following types of ingredients may be added:

(1)—Vulcanizing agents
(2)—Vulcanizing accelerators
(3)—Accelerator activators
(4)—Accelerator retarders
(5)—Antioxidants
(6)—Plasticizers
(7)—Stiffeners
(8)—Reinforcing materials
(9)—Inert fillers
(10)—Pigments and coloring agents
(11)—Rubber substitutes
(12)—Odorants
and, for special purposes,
(13)—Blowing agents, for sponge rubber
(14)—Abrasives, for erasers or grinding wheels

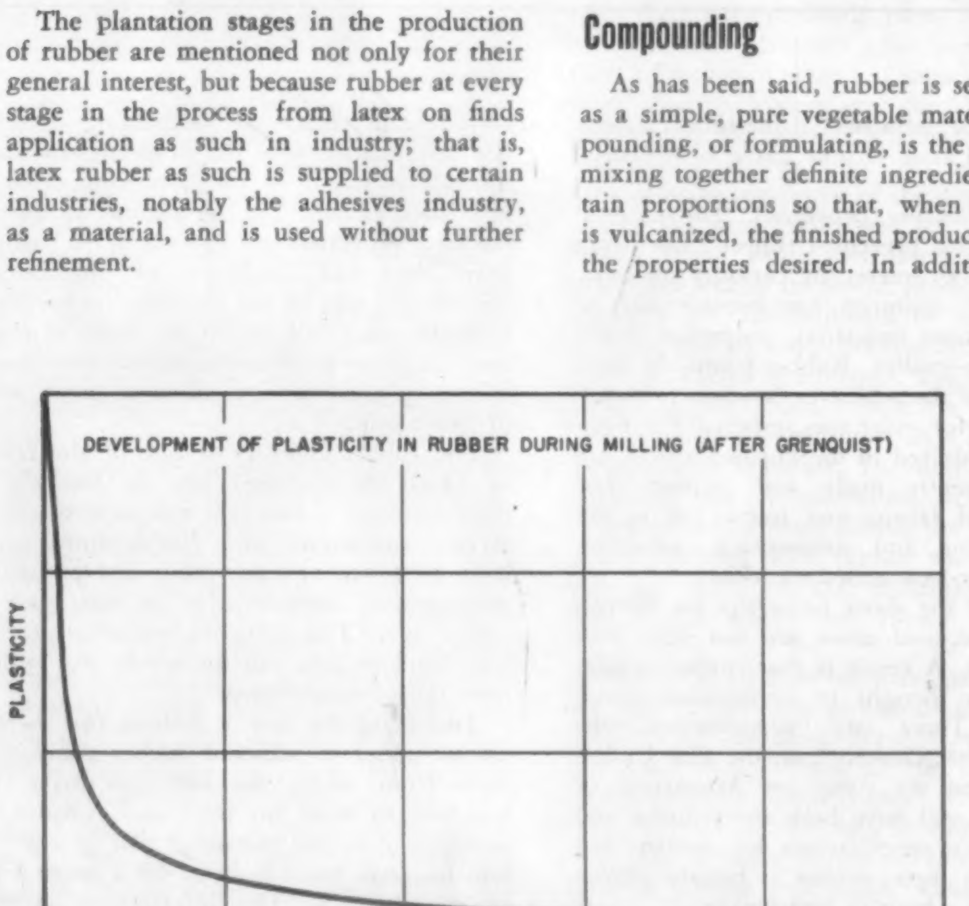
Rubber—Choice of the type of rubber will be influenced by the properties required, cost, and availability. The two premium grades are the "first latex rubbers," smoked sheet and pale crepe. Smoked sheet can be used for high-grade articles subject to wear and tear, such as tire treads, tubes, footwear, wire insulation, and shoe soles. Pale crepe rubber is practically colorless, clean, and usually commands a slight premium over smoked sheet. It is preferred for articles that must have transparency, high whiteness, or must be made in delicate colors.

The lower-grade plantation rubbers, usually cheaper than smoked sheet, can be used alone, or with the higher-cost grades to lower costs, or to increase plasticity. Guayule, obtained from the plant of that name, is sometimes incorporated with the other rubbers to soften friction mixtures.

Reclaimed rubber is now a standard product, sold in many grades, and used by the rubber industry in the overall proportion of 1 to 3 of new rubber. While it is usually avoided where the greatest possible resistance to wear and tear, rupture, or aging is needed, it finds use in compounding to aid in milling, to smooth calendered or extruded work, and to increase the output of extruders. It is especially used in mechanical goods, footwear, hard-rubber articles, electrical goods, and novelties. Novelties can be made entirely of reclaimed rubber.

Vulcanizing agents—Although vulcanization can be accomplished with many substances, sulfur, the first used, is still the principal one used. Smaller quantities are used now than formerly, with an improvement in the goods made. Present ratios are in the range of 1.5 to 4.0% of the weight of the rubber in the formulation for soft-rubber articles; 6 to 10% would have been typical a decade or more ago.

When good tensile strength at elevated temperatures, or good heat and aging resistance are necessary, low-sulfur vulcanization may be used. In this case selenium or tellurium in low-sulfur compounds are the vulcanizing agents. Some sulfurless vul-



Plasticity of rubber increases during milling. The method of milling overcomes some of the elasticity inherent in rubber.

anization, in which sulfur-containing organic compounds are used, is now commercial.

Vulcanizing accelerators—Another ingredient is added to speed up the rubber-sulfur reaction. These accelerators are of two kinds, organic and inorganic. The first type is by far the most used in present-day rubber compounding, and includes the ultra- and semiultra-accelerators. Under organic are: (a) benzothiazole derivatives; (b) thiuram sulfides; (c) salts of dithio acids; (d) guanidine derivatives; and, (e) aldehydeamines. Inorganic type accelerators are of older types, now used in only a few compounds: (a) lime; (b) litharge; (c) other lead compounds; and, (d) magnesia.

Of the accelerators, the first three organic types are most common. They cause more rapid vulcanization and generally give somewhat better physical properties in the finished product. Lime is sometimes used in hard-rubber products.

Accelerator activators—Activation of the ingredient that accelerates the vulcanization reaction requires that another substance be included in the formulation. Accelerator activators are usually metallic oxides, and one of them, zinc oxide, is added to nearly all rubber formulas. Litharge is another sometimes used.

A second group of accelerator activators is composed of organic acids, stearic, oleic, or lauric. Stearic acid is added to most rubbers using benzothiazole accelerators.

Accelerator retarders—Retardation of the vulcanization process is not often necessary, but in some formulations it is advisable to add another ingredient to prevent partial vulcanization during the milling of the compounded rubber. Too rapid vulcanization may cause "scorching" of the material, and a retarder can be useful here also. The most common retarders are salicylic, phthalic, or benzoic acids, or some of the phenols.

Antioxidants—To reduce the deleterious effects of oxygen upon the finished article of rubber, it is now common practice to include a small quantity of an oxygen-remover in the formulation. The antioxidants tend to retard the "aging" of rubber after its processing has been completed. They are organic chemicals, usually sold under proprietary names.

Plasticizers—Milling of rubber may be assisted by treating the rubber with a softener. The effect of the softener, or plasticizer, is to swell the rubber slightly so that it becomes plastic more quickly during the milling operation, and so saves time and power. The effectiveness of the various plasticizers, and the amount added, varies considerably, and depends to a considerable extent upon the other ingredients in the formulation. Thus, if stearic acid is added as an accelerator it will also help to lubricate the mass. In general, formulations containing small proportions of fillers or reinforcing agents will require several percent of plasticizer to permit smooth calendering or extruding.

Some of the commonly used plasticizers are:

- Pine tar—much used in tire treads
- Waxes (ozokerite and paraffin)—for extruded insulation for wire
- Coal tar—for shoe soles and heels
- Mineral oil—for general use

Stiffeners—When extruded parts must maintain the form given them during a period of time prior to vulcanization, it is sometimes necessary to add small amounts of a substance to decrease the plasticity slightly. Benzidine or para-aminophenol, or occasionally litharge, will serve this purpose.

Reinforcing materials—Certain powdered materials increase the stiffness and strength of rubber vulcanizates, and impart greater resistance to tearing and abrasion. Few formulations are made with "pure gum," as such unfilled material would lack strength. These reinforcing materials are used in relatively large amounts in most rubbers. The most common are:

- Carbon black, best grade—for greatest tensile strength, abrasion and tear resistance, greatest stiffness
- Carbon black, soft—for good strength, tear, and abrasion resistance combined with softness and pliability
- Zinc oxide—for white rubbers with good strength and softness
- Magnesium carbonate—also for white rubbers
- Clay—for white rubbers with good tensile strength and stiffness but lower resistance to tear and abrasion
- Calcium carbonate (blanc fixe)—good strength and better tear resistance than clay-filled compositions

Inert fillers—When stiffness, hardness and weight can be added to a rubber composition, but good strength and abrasion resistance are not needed, an inert filler can be used. It serves merely as a diluent or bulking material, and so reduces cost. Included in this group are infusorial earth, some kinds of clay, slate flour, some types of whiting, barytes, and other ground minerals; asbestos for heat-resisting compounds; and hard-rubber dust for hard-rubber compounds.

Pigments and coloring agents—Mineral pigments have given way to a considerable extent to organic dyes in the coloring of rubber articles. White pigments include titanium dioxide, zinc oxide, zinc sulfide, and lithopone.

Rubber substitutes—Several compounds having a superficial resemblance to rubber may occasionally be added to a formulation. In the manufacture of erasers and soft rubber rolls a spongy material called factice, made by heating vegetable oils with sulfur or sulfur chloride, is sometimes used. Another group, including asphaltic and bituminous derivatives, finds use as bulking agents, as softeners, and as low-cost fillers. They also aid in extrusion, and are used in compositions for wire insulation because of their good electrical properties. Their use is limited to black goods.

Several of the synthetics, when compounded with rubber, are considered to be in this group of ingredients. Chloroprene can be added to increase oil resistance or decrease electrical corona. Polysulfide synthetics have excellent chemical resistance, and may replace rubber wholly or in part when oil resistance is required.

Odorants—For a few articles intended for personal or household use, very small amounts of essential oils or of pleasantly scented organic materials are sometimes added to the rubber formulation to disguise the characteristic odor of rubber.

Blowing agents—Sponge rubber is made by including a gas-forming agent in the formulation, so that the heat of vulcanizing will liberate the gas that blows up the sponge. Sodium bicarbonate and ammonium carbonate are the chemicals used to form the sponge.

Abrasives—Mineral ingredients such as pumice, silica, carborundum, and tripoli are included in rubber formulations for such items as hard or soft rubber grinding wheels and rubber erasers.

Vulcanizing

The object of milling the raw rubber is to convert it from an elastic condition to a plastic state. In this state it is compounded, and undergoes a forming process. The next step is to change it from this plastic condition to one in which it will possess greater elasticity. It is not a reversal, but some of the properties tend in that direction.

Vulcanizing increases the tensile strength of the material, decreases stickiness, and decreases solubility (or swelling) in most of its solvents. For most practical purposes, it consists of heating with sulfur. If soft-rubber vulcanization is sought, the formulation will contain about 1.5 to 4.0% sulfur, based upon the weight of rubber in the formula. Hard-rubber vulcanization will call for about 30 to 45% sulfur.

Several representative classes of rubber goods use the following percentages of sulfur for vulcanization:

Molded tubes	0.75 to 2.5%
Footwear	2.0 to 2.5%
Tire carcasses	2.5 to 3.5%
Mechanical goods	2.5 to 3.5%
Tire treads	2.75 to 3.25%
Shoe soles and heels	3.0 to 4.0%

Use of accelerators has decreased the time of vulcanization from the 3 to 4 hr. at 250 F of years ago to about 5 to 50 min. today. The smaller amounts of sulfur that can now be used reduce the sulfur "bloom" that

frequently marred the appearance of rubber goods in the past.

There is good reason to believe that the use of vulcanizing agents other than sulfur, now used to a limited extent only because of the cost of the process, will become more widespread in the near future. Greater heat resistance and better aging properties are the advantages to be gained.

Forming

Forming precedes vulcanization in the case of extrusions, is nearly synchronous with it in the case of molding, and follows it in the case of lathe-cutting or die-cutting. The rubber may be sheeted from the mill after milling and compounding have been completed, the sheets vulcanized, and pieces cut from them by die-cutting, or cylinders may be formed on a mandrel and lathe-cut, after vulcanizing.

Extruding—Nearly all rubber compounds with a Durometer hardness value higher than 45 to 55 can be extruded. Continuous strips can be extruded through dies of any shape from power-driven tubing machines. The extrusions are either coiled or laid in lengths in large flat trays, and vulcanized in open steam heaters. Electric wire insulation is extruded over the conductor in one of the most familiar applications of extruding of rubber.

Some of the features of the extruding process are:

(1) Extruding dies are much less expensive than molds.

(2) Extruding is adaptable only to linear forms of uniform cross-section.

(3) The usual tolerance in dimensions in the cross-section are plus or minus 1/32 in. Closer tolerances can be held in at least one dimension, but unit costs will be higher.

Molding—Rubber is not melted and poured like metal, but is forced into the mold under high pressure. Molds should be of heavy metallic construction. In addition to the special shapes, for which it is necessary, molding is sometimes used for sheet or linear shapes because of the closer control of dimensions possible by this method, and the better finish of the surfaces obtained.

Dimensions can be held to a tolerance of plus or minus 0.007 in. per in. Closer tolerances can be held by close supervision of compounding and processing, but at higher cost.

The minimum size mold for economical manufacture is about 22 in. by 22 in. They should be equipped with prodder lugs, register lugs, and dowel pins. Cavities should be far enough apart to allow space for overflow cavities.

Complicated shapes sometimes require molds of three or more plates. Hollows in the part can be obtained by using solid mandrels; floating mandrels can sometimes be used when the shape does not permit anchorage. In other cases the hollow space can be formed more economically by inflation. High-pressure molding (150 to 200 tons on press plates) affords greater freedom from porosity, more uniform product, fewer slack-filled cavities.

Trimming can be done by die, by hand buffing or cutting, or by tumbling. Tumbling eliminates luster finish and rounds corners slightly.

Cotton fabrics, steel, and some kinds of brass can be attached to rubber during the molding process. Vulcanizing takes place at the latter part of the molding cycle.

Lathe-cutting—When such items as circular washers, disks, or cylinders are to be made, lathe-cutting is the process most likely to be used. Unvulcanized rubber compound in sheet form is wrapped around a core or mandrel, or extruded compound may be used. Vulcanization in open heat follows, and the rubber cylinder is then cut into the series of shapes on a lathe.

Tolerances must be greater than for molded articles.

Die-cutting—Rubber compound may be sheeted from the mill, vulcanized, and then cut into any flat form in dies much as metal would be stamped out from a sheet.

In addition to the above forming methods that follow as proper steps in the manufacture of rubber from crude, there are several other forming techniques that will be mentioned here only in passing, as they are more properly concerned with rubber as a special material than with forming. Rubber products can be made directly from latex by dipping or spraying forms, or by electrodeposition. Also, by including a blowing agent in the formulation, rubber can be molded as a sponge, the blowing being accomplished simultaneously with vulcanization in the mold.

Articles of molded sponge rubber must be given liberal dimensional tolerances.

Rubber as a Material in Industry

The materials engineer, and the engineer in industry outside of rubber manufacturing, is primarily concerned with rubber as it leaves the fabricating procedures and fits into machines and equipment in which it is, usually, a very small part. He is interested in the properties of the various types of rubber available to him, and in the limitations of each type.

Unfortunately, there is no place in the manufacture of rubber at which it can be said to be strictly a raw material, or a semi-finished material. As has been pointed out before, rubber at every stage from the natural latex on is supplied to industry outside of the rubber manufacturers. The accompanying chart will show how industry takes rubber in various stages of finishing.

Rubber is offered as an industrial material in latex form, as preparations of crude rubber, as manufactured rubber, reclaimed rubber, hard rubber, and as certain specialized rubber derivatives.

Properties and Uses of Latex

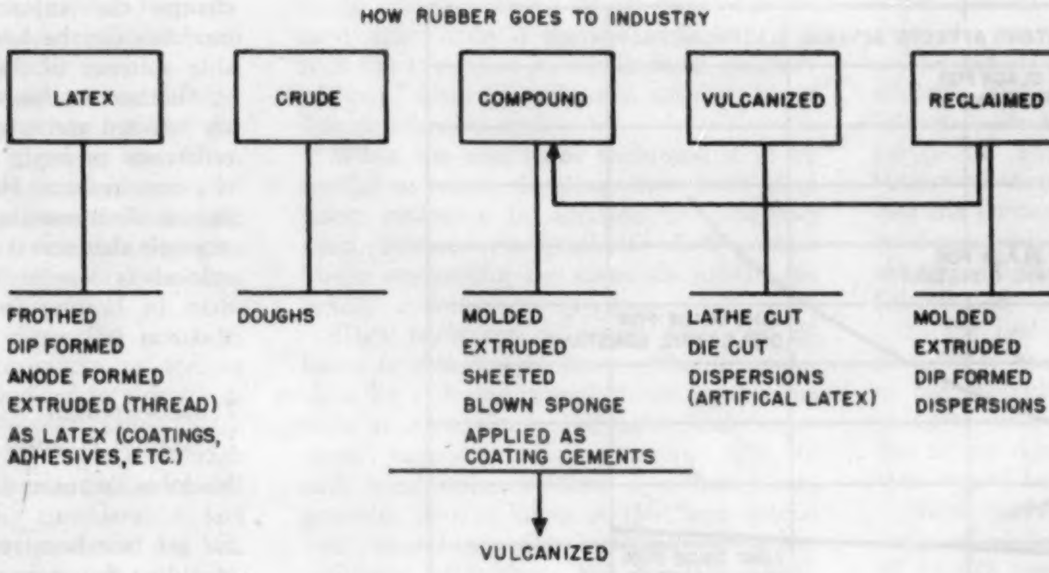
Latex goes into industry in three forms: (1) creamed, (2) centrifuged, and (3) normal. For (1), a creaming agent, such as glue or gelatin, is added to the natural latex. It may then be diluted with water, and again creamed to affect a certain amount of washing of the rubbery particles. The washing makes it more desirable for certain applications, as electrical insulation. It is concentrated to about 60% rubber content for the most part. The (2) type is concentrated by centrifuging to about 60% latex also, and is stabilized with ammonia for preservation over a period of time. The normal latex, stabilized with a mineral alkali, usually potassium hydroxide, is evaporated to a solids content of about 65 to 68% dry rubber.

Latex should be protected from prolonged contact with iron, especially if any putrefaction of the vegetable product has occurred. A wax coating over the interiors of the drums is customary.

Latex can be used as received, or compounding ingredients can be added, usually as water dispersions. The shoe industry uses plain latex as an adhesive for holding the leather parts of a shoe together during fabrication. It also goes into some phases of the textile industry.

Latex for vulcanizing has the advantage of being able to utilize the ultra accelerators in formulating, as there is no milling process to generate heat and cause prevulcanization. This makes it possible to complete vulcanization at low temperatures, below 212 F, and so heating in closed vessels under pressure is not required. This process is widely used in the waterproofing of fabrics, and in impregnating of felts.

Rubber deposited from latex is remarkably strong for an unvulcanized material, and will permit combining with a large proportion of a cheap softening agent, such



as mineral oil. This mixture is commonly used in making toy balloons and similar novelties.

Latex can be vulcanized without coagulation, and the ready-vulcanized coagulum offered for sale as a standard commodity. It is suitable for many uses without further vulcanizing.

Another type of latex is available also. It is the artificial latex made from compounded rubber or rubber reclaim. Actually only a water dispersion of finished rubber, these artificial latices are offered for many purposes for which the natural latex is also used. They may be made by milling a soap into the rubber, then adding increasing amounts of water to the mixture on the mill, until the water holds the rubber particles in a dispersed state.

One of the principal uses of the latices is in *latex dipping*. The process is, essentially, the forming of rubber articles over a mold or form by immersing it in a latex. Simple mechanical dipping, in which the mold with adhering rubber was removed from the solution, the rubber stripped off, dried, and, usually, vulcanized, is now little used, but the same general procedure is speeded by use of coagulants and by use of electric currents.

Toy balloons can be made in a single dip by wetting aluminum forms with a coagulant and immersing in compounded latex. The same process will produce seamless gloves, bathing caps, beach shoes, ice bags, etc. Rubber can be coated onto metal, as in the insulated grips on electrician's pliers, or onto cloth, as in cloth-lined play shoes. Vari-colored effects can be obtained by streaking or spotting the surface of the form with organic dyes before dipping. A wrinkled or roughened finish can be produced by using a solution containing agents for both coagulation and swelling, as acetic acid and benzene. Beach shoes with sponge rubber soles are made by dipping calendered rubber lasts into frothed latex.

Electrodeposition is done in a bath of low alkalinity to avoid liberation of gas at the anode, where the piece is formed. The process is essentially a migration of coagulant cations from the surface of the anode so that rubber particles are coagulated there. A current density of about 1 amp. per sq. dm. is used, and the yield is high—about 3 grams of rubber are deposited per amp. per min.

The anode is zinc or zinc-plated iron if the article is to be removed, and usually iron or steel if it is to be permanently covered. Woven steel wire mesh is rubber-covered by this method.

When an article must be free from any gas pinholes, and must be easily removable from the mold, a porous former of unglazed clay may be placed around the anode. An electrolyte in the former, such as a solution of calcium chloride, provides conduction. Compounded rubber will be deposited on the form, and when built up to the desired thickness can be removed, dried, and vulcanized.

Latices can be used for *molding* also. In this case the latex is poured into a mold, a small amount of a coagulant is added, and the temperature is raised to about 160 F. About 3 parts of calcium sulfate per 1000 of rubber is a coagulant used with good results. When the mixture has set the form is removed from the mold and vulcanized.

Because of the moisture freed by coagulation, this method of forming is suitable for thin articles only. Shoe soles, tubes, and similar forms are made by this method.

Porous molded articles can be made by using latex of a controlled concentration, so that the freed water creates tiny pores in the material. Battery diaphragms are so made.

Larger voids are created by adding a gas or gas-forming agent to the latex. The material called frothed latex can be conveniently made by whipping air into the latex, and then molding.

Crude Rubber

Crude rubber is used to only a small extent as a semifinished material. By far its largest use is in the rubber industry, as an ingredient in formulas for manufactured rubber. Some of it is made up into cements and doughs, however, and in that state becomes a basis for raw rubber adhesives. Frequently such adhesives are cured after use.

The special advantage of crude rubber (raw rubber) in making up cements and doughs is a peculiarity in the behavior of rubber. Vulcanized rubber, which is exposed to liquid hydrocarbons—turpentine, benzene, gasoline, mineral oils—and to most vegetable oils except castor oil, and to certain other solvents, such as carbon tetrachloride, carbon disulfide, and ether, will swell to an approximate maximum. Unmilled crude rubber behaves in much the same way. Milled crude rubber, however, takes up the liquid gradually, and diffuses throughout the entire liquid to form a viscous solution, or cement. If the concentration of the rubber is about 10 to 20% or more, the mass becomes a stiff dough. Milling will greatly decrease the viscosity of these cements and doughs.

Crude rubber has a tensile strength much lower than that of good vulcanized rubber; its elasticity (stretchability) is lower, and is maintained over a narrower temperature range. It is greatly affected by the speed of stretching, recovery being much less complete as the rate of stretching becomes slower. The relative tensile strengths of crude rubber and of a well-vulcanized rubber are approximately:

Crude rubber—about 150 psi.
Pure gum vulcanizate—about 3000 to 4000 psi.

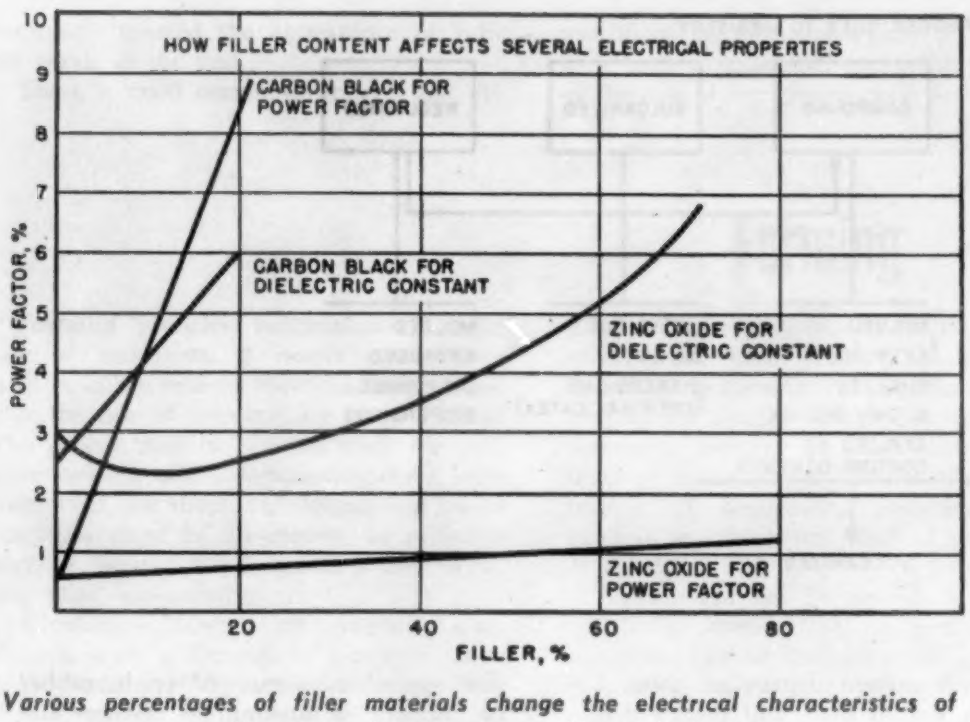
Small amounts of copper or manganese adversely affect crude rubber, causing extreme tackiness.

Manufactured Rubber

The forms of manufactured rubber and the general limitations of each method of fabrication have been briefly discussed. In considering the properties of the manufactured rubbers, it is convenient to divide them into general groups based upon rubber content, and to illustrate each group with typical products made with that rubber content.

Gum Rubbers, 96 to 80% Rubber by Weight

Pure gum rubbers are those that contain



Various percentages of filler materials change the electrical characteristics of rubber to varying degrees, as this graph shows.

no filler, but are composed of rubber and vulcanizing and protective ingredients only. Typical products are: Surgeons' gloves, toy balloons, transparent rubber articles, rubber bands, pure gum tubing, and surgical goods.

Compounds 80 to 50% Rubber

Physical properties will vary widely in this group, depending upon the type of nonrubber constituents. In a tire tread much of the filler may be carbon black, while a hard rubber will include much sulfur. Some products are: Sponge rubber articles, ebonite, auto tire treads, inner tubes, household gloves, footwear, and 60% cable covers.

Compounds 50 to 30% Rubber

Typical products in this classification are: Many types of hose, mechanical goods, tubing, 40% cable covers, shoe soles and heels, toys and novelties, hospital sheeting, tank linings, water bottles, 30% insulation, and rainwear.

Compounds 30 to 10% Rubber

This group includes some of the cheapest and some of the most expensive formulations. Rubber substitutes may replace rubber for special purposes, or the material may be heavily filled. Products include: brake linings, oil-resistant items, auto topping, floor mats, packing and gaskets, floor tile, code wire insulation, and clutch facings.

Most tabulations of the properties of rubber give the properties of the pure material as determined in the laboratory. While these results are helpful to a certain extent, they are not the properties obtained in compounded rubber as used in manufactured articles. Such properties could be given accurately only for each formulation, but some idea of the trend of change in them can be given, so that the engineer may estimate properties obtainable in the manufactured rubbers. This should not be taken as a guide for specifying, or even suggesting, formulations to the rubber manufacturer. Compounding is much too complicated a procedure, involving balancing of the effects of many ingredients with properties desired and with operating procedure in rubber fabricating, to be undertaken with the knowledge of the general effects of a few ingredients.

Pure gum rubbers—A "pure gum" formulation may be used as the basis for other mixtures, or may be used as supplied. It will probably contain, in addition to the rubber and the sulfur for vulcanizing, a small amount of accelerator for the vulcanizing reaction, probably an organic accelerator. The metallic oxide that activates the accelerator may well be zinc oxide, and stearic acid may be added in small quantity for its help with vulcanizing, and for its plasticizing effect. A little antioxidant will probably be added.

Pure gum rubbers are selected when the greatest degree of elasticity is required, combined with low modulus and flexibility. A rather slow-vulcanizing rubber could be expected to have:

Modulus, at 500%	— 300 to 400 psi.
Tensile strength	—3000 to 3500 psi.
Elongation at break	— 825 to 850%

By using a more active accelerator to increase the rate of vulcanization, the strength of the rubber can be increased to:

Modulus, at 500%	— 600 to 800 psi.
Tensile strength	—4000 to 4500 psi.

If, on the other hand, it is desired to lower the modulus and to hold the elongation high, the rate of vulcanization might be reduced. When it is not feasible to change the vulcanizing ingredients, the modulus can be lowered by adding a suitable softener to the formulation.

Another use for which pure gum rubbers are selected are surgeons' gloves, for which resistance to heat, *i.e.*, steam sterilization, is a requirement. Heating rubber to 212 F causes deterioration, though the loss of strength that serves as a measure of deterioration is less in the absence of oxygen than in heating in air. The changes are about as follows:

	At 40 F	*At 212 F*
Tensile strength	4,500 psi.	1,500 psi.
Elongation at break	500%	450%

Modulus decreases as temperature increases.

To get best heat resistance, the percentage of sulfur for vulcanization is kept as low as possible.

Pure gum compounds are usually more difficult to calender and extrude than mixtures containing a substantial percentage of filler. A softener is sometimes added to help in processing. The amount of softener may be as much as 10%, and mineral oil or a specially processed oil may be used.

Transparency is sometimes desired in these compositions, and this necessitates holding the zinc oxide content low, keeping sulfur to a minimum without increasing the amount of accelerator, and sometimes use of pale crepe rubber in the formulation.

Resistance to wear and abrasion is always low in the unfilled compositions. Sunlight and ultraviolet light cause deterioration, as shown by loss of tensile strength. Surface cracking frequently appears, especially if the rubber is under tension.

For electrical uses, gum rubbers are specialties for the most part, as most insulations must have a degree of wear resistance also. Its properties so far exceed requirements that the engineer is more concerned with eliminating defects than with dielectric constants.

Filled rubbers—Rubber formulations containing only rubber and vulcanizing and protective ingredients have limited applicability. The various fillers, both inert and reinforcing, play a large part in developing those properties that make rubber an important engineering material today.

A significant example of the value of ingredients in compounded rubbers can be found in the development of present-day automobile tires. The tires with which the automobile industry was first equipped were notoriously unreliable even in that day of slow-moving vehicles. It has been estimated by rubber authorities that a tire made of the purest and best crude rubber would last scarcely a thousand miles. Until World War I automobile tires were made with the best quality zinc oxide as a filler. They lasted about 5000 to 6000 miles. The shortage of zinc during the war led to the use of carbon black as a substitute. This was the beginning of the black tire, which proved so superior to the white tire used until then that there was no return to the prewar tire. Use of carbon black as a reinforcing filler has become well estab-

lished, and at present the rubber formulations possessing the highest tensile strength are made with carbon black.

Zinc oxide is still used as one of the principal ingredients in white rubber, for which it serves as a pigment and filler. For red rubber, red oxide of iron is the most generally used pigment. The wide range of colors possible in rubber articles is largely a tribute to the organic dyes available.

When color is not important, but high tensile strength and resistance to tearing and abrasion are required, as in tire treads or conveyor belting, channel carbon black will probably be used in high percentage in the formulation. It lowers resilience and flexibility of the rubber considerably, and these factors may limit its use if the belt is fast-running and so subject to considerable flexion.

For electrical applications, the 60%, 40%, etc., cable covers contain approximately that amount of rubber. Zinc oxide is much used as a filler in white insulation rubbers, as is whiting. The effect of zinc oxide and of carbon black as fillers is shown in the accompanying curve (Fig. 3).

The dielectric constant of rubber formulations is also important in electrical work. Dielectric strength is the third of the usually required values. Some generalized values for the dielectric constant are given in the curve showing electrical properties. Conductivity is the remaining property regarded as important in judging the suitability of a rubber compound for an electrical use. Some general values:

Dielectric strength (cable insulation tested) about 20 kv./mm., or 500 v./mil.

Conductivity about 1.5×10^{-15} mho./cm. Values of electrical properties are especially subject to change; absorption of water, seemingly through the filler, causes an increase in the dielectric constant, power factor, and conductivity.

For ordinary vulcanized rubber, 150 F can be taken as a safe temperature limit to be observed in fixing service conditions. Special formulations can be used to 200 F, or somewhat higher. Inasmuch as deterioration is a progressive process, exposure to temperatures above the safe working limits results in a lowering of tensile strength. In rubbers vulcanized with low sulfur and containing very little excess sulfur, higher temperatures cause a softening of the material. Those formulations made with larger amounts of sulfur for vulcanizing, and containing appreciable amounts of free sulfur in the vulcanized stock, will show a tendency to harden as the temperature exceeds the working limits, due to an after-vulcanizing of the rubber. Flexing or tensile stress combined with the excessive temperature will cause surface cracks to appear at the stressed points.

Gasket or packing material intended for elevated-temperature service may use rubber to bond asbestos fabric or shredded asbestos. Brass or other metal wire inserted sheeting is made for the same purpose.

Use of mineral fillers is one of the most common formulating methods for developing heat resistance. Of the mineral fillers used, zinc oxide is the most effective, but it is too expensive to use in large quantity without "diluting" with clay, whiting, blanc fixe, or other mineral.

When the heat to be withstood is to be applied as steam, the fillers must have good water resistance in addition to imparting good thermoduric qualities. Soft carbon blacks are among the materials usually selected.

High resistance to water, acids, or alkalies is obtained in most rubber formulations by avoiding water-soluble ingredients such as glue, lime, and salts, and sometimes water-soluble accelerators. Use of such water-resistant fillers as carbon black, graphite, certain kinds of clay, and special zinc oxides actually increases the water resistance of rubber. For acid- or alkali-resistance, however, the fillers must resist attack by those substances, and this militates against zinc oxide, whiting, lime, etc., in compositions to resist acids, and zinc oxide in alkali-resistant formulations.

Resistance to oils can be increased, but swelling cannot be eliminated, by compounding with the oil-resistant synthetics, especially chloroprene or polysulfide types. Some rubber is usually included in the formulation in spite of its susceptibility to attack because of the poor strength of the synthetics, and to lower the cost. Resistance is also obtained by loading with reinforcing agents, and by vulcanizing harder than would otherwise be the case. It is easier to obtain a degree of oil resistance in hard and stiff rubber articles than in those that must have considerable flexibility, as the effect of both heavy loading and hard vulcanizing is to stiffen the finished rubber. When oil resistance must be combined with softness and pliability, the use of factice or similar rubber substitute is a common expedient.

A problem that arises in electrical insulation apart from the strictly electrical properties of the rubber is the effect of ozone upon the insulation. This ozone, present in small amounts near high-tension wires and electrical discharges, rapidly attacks rubber, causing severe surface cracking. The best solution found so far is the incorporation of a percent or two of wax in the formulation. Paraffin, ceresin, and ozokerite are so used. Coating of the rubber surface after forming is another means of combating the trouble.

Foam and sponge rubbers—Use of a gas or gas-forming ingredient in fabrication of rubber to produce a lightweight, porous material has given industry a new product. These microporous rubbers can be produced in two ways: Adding a gas-former to rubber during milling, or to latex, the gas being released during vulcanization, and, whipping air or a gas into latex and vulcanizing. These have already been mentioned. Another development of the same structure is porous hard rubber, used in the making of diaphragms, especially for electrical storage batteries. In this case the structure is obtained by vulcanizing wet coagulated and compounded latex to hard rubber, without using a gas-former. The water present in the prevulcanizate produces the pores.

The density and size of the pores is controllable within limits, its density usually falling inside the range 0.004 to 0.025 lb. per cu. in. This low density is its principal feature. Because of the large exposed surface the porous rubbers are especially liable to deterioration by oxygen and sunlight, strong antioxidants are included in the formulation.

In the case of porous hard rubber, the porosity is controllable through regulation of the proportion of water in the mixture going to vulcanization. The pores are very fine in any case; a diameter of about 0.0004 mm. would be average.

Hard rubber—Addition of sulfur in a range of about 25 to 45% instead of the ½ to 4% used for soft rubber causes the formation of a hard, hornlike material almost entirely without flexibility. It is chemically inert, possesses good strength, excellent electrical properties, and good appearance, and is one of the standard materials in the rubber category.

There are few rubber compounds using sulfur for vulcanization in percentages between these two groups. A few such compositions are produced, and are called semihard rubbers.

Hard rubber possesses good resistance to aging, and after many years of exposure to air seems to be unaffected. It suffers perceptible deterioration upon exposure to sunlight, however, with the formation of a film of sulfuric acid upon its surface. This greatly increases its electrical conductivity. It possesses high chemical resistance, being superior to soft rubber in this respect. Only the rubber solvents, such as benzene and carbon tetrachloride, and strong oxidizing acids, such as nitric and sulfuric, will attack it. It resists attack by most gases, but resistance falls off slightly at temperatures above about 120 F.

When heated, hard rubber gradually softens, and becomes quite flexible at about 212 F. Above that temperature gradual deterioration occurs, and at about 500 to 535 F the material melts to a jet-black resin. The melt becomes hard and brittle upon cooling, and if again heated it softens at about 175 F. This product has been used to repair defects in hard-rubber parts, and as a binder in grinding wheels.

Use of mineral fillers in hard-rubber compositions results in a considerable lowering of impact strength. Ground hard rubber is a filler much used, as it has little effect upon impact strength but greatly reduces mold shrinkage. Reclaimed rubber is much used in hard-rubber compounding. Whiting, clay, and asbestine are used in some compositions to improve hardness and obtain greater heat resistance, and a few percent of such softeners as waxes, vegetable oils, and resins may be used to obtain smooth working properties.

Tensile strength ranges from 4000 psi. to 11,000 psi., with the higher values obtained with completely vulcanized material. Elongation varies from about 20% at the low end of the sulfur percentages to about 2% with 45% sulfur.

Electrical properties for hard rubber are somewhat better than those for soft rubber, due mostly to its greater stability in the presence of moisture. Some typical values:

Dielectric constant—about 2.7 to 3.0 at 60 F (temperature rise has a marked effect).

Power factor—about 0.3 to 0.8 at 60 to 3000 cycles, about 0.7 to 0.9 at 300,000 cycles.

Dielectric strength—100,000 to 150,000 volts per mm.

Water absorption — low — about 0.3% after many months' immersion.

The impact strength of the hard-rubber vulcanizates is of great importance to the engineer. The Izod impact strength of a hard rubber made without filler of hard-rubber dust and without softeners should be of the order of 0.18 to 0.25 ft.-lb. Use of hard-rubber dust as a filler will decrease the impact strength slightly.

Reclaimed rubber is frequently an ingredient in hard rubber. It is not only cheaper than crude rubber, but reduces vulcanization time and cure temperatures also. Properties are not adversely affected to any important degree, and processing is improved. However, vulcanization accelerators have not been developed as successfully for the high-sulfur formulations as for the soft rubbers, due largely to the danger of "scorching" if an accelerator is used in connection with the large amount of sulfur present. Hard-rubber vulcanizates are frequently made without any accelerator, or with a small percentage of calcined magnesia or lime.

Hard rubber is used for storage battery partitions, storage battery cases, fountain pens, combs, chemically resistant piping, electrical parts, etc.

Reclaimed rubber—Reuse of scrap is an important factor in the economics of any material, and rubber is no exception. Processing of the material is somewhat more complicated than is the case with most of the metals, but the reclaimed material has won such a place for itself in industry that it is used in normal times in the proportion of about one pound to every two of new rubber.

Rubber is prepared for reuse by one of several variations of a chemical process involving "devulcanizing" with caustic soda solution, washing, drying, and milling. As the vulcanizing reaction is reversible, there is no true devulcanization, but the process produces a material that compares in some respects to unvulcanized rubber. The finished reclaim may be compounded with new rubber, or can be fabricated by itself for some purposes.

In addition to the obvious advantage in cost, reclaimed rubber has the following advantages in physical properties or processing:

(1)—The rate of vulcanization is increased. This may be utilized by reducing the amount of accelerator, while still obtaining good properties in the vulcanizate.

(2)—Reclaimed rubbers, and formulations containing reclaimed rubbers, are more easily extruded. Their freedom from "nerve" means greater plasticity without long milling, and results in savings in time, power, and labor costs.

(3)—Having been blended during its original manufacture, and blended again during reclaiming, reclaimed rubber is uniform in its properties. A certain amount of segregation of scrap takes place before the reworking process, giving rather definite properties to the batch.

(4)—Properties can be controlled to a degree during the reclaiming process. Segregation of scrap, as mentioned above, is one way of controlling properties. The reclaiming process itself permits variations that will affect properties.

Reclaimed rubber goes into the formulation for such articles as shoe soles and heels, waterproof footwear, mechanical goods, electrical items, rainwear, and novelties. It lacks strength and abrasion resistance to the degree required for such rubber items as tire treads, and is not used where these properties must have maximum value. Many small novelties are made entirely of reclaimed rubber, however.

Rubber derivatives—In addition to the uses of rubber itself as a material, there are several materials obtained by chemical modification of rubber. They are commercially important mostly as adhesives or coatings. These rubber derivatives may be grouped as:

(1)—Cyclized rubbers
(2)—Chlorinated rubbers
(3)—Rubber hydrochloride
(4)—Oxidized rubbers

Cyclized rubbers are formed by a molecular rearrangement of the rubber, induced by the action of acid reagents and heat. The products are thermoplastic in nature, and some of them are suitable for use as molding compounds, resembling hard rubber in appearance. Most of these cyclized rubbers are inelastic, melt at temperatures from about 240 to about 500 F, depending upon the chemical treatment given, and possess about the same chemical resistance as hard rubber.

Best known of the cyclized rubbers are the materials referred to in various modifications as the thermoprenes. They are prepared by treating rubber with sulfonic acids and other organic cyclizing agents on a roll mill. By varying the concentration of the chemical and the extent of treatment, compounds ranging from rubber-like materials of low elasticity to hard materials resembling shellac can be obtained. Some of the most successful rubber adhesives are made from thermoprenes, and they have been widely used to join rubber to other materials, such as metals, wood, and concrete. The bond softens at about 140 F, however.

Chlorinated rubber, made by passing chlorine gas through a solution of rubber, is usually offered as a light-colored powder, inelastic, and with high chemical resistance. It finds its chief use in corrosion-resistant paints. It undergoes slight decomposition at temperatures in the neighborhood of 212 F, and the rate of decomposition increases irregularly as the temperature rises. The material will not burn, but will char without melting at temperatures above about 450 F.

Benzene and its derivatives, carbon tetrachloride, trichloroethylene, carbon disulfide, and most chlorinated solvents will dissolve chlorinated rubber. It is quite resistant to the action of most mineral acids and to strong alkalies.

When used as a paint or varnish the chlorinated rubber is taken up with toluene, xylene, or solvent naphtha; 15 to 30% rubber content is typical. A plasticizer is added if the film must possess some degree of flexibility.

Rubber hydrochloride is finding some use as a material for thin sheets of flexible, transparent wrapping and packing film. It has good strength, is resistant to oil and grease, and forms a good moisture barrier. It is readily heat-sealed at about 220 to 250 F.

The material is prepared much as is chlorinated rubber, except that hydrochloric acid gas is passed into the solution of rubber.

Oxidized rubbers, in which latex or manufactured rubber has been treated with an oxidizing agent, are finding some use as ingredients in paints, flexible coatings, and for some types of insulating coatings for electrical parts. The most promising field of usefulness for these oxidation products seems to be in paints, as they possess the interesting property of being thermosetting, and harden upon exposure to temperatures of about 212 F. They can be made to produce an insoluble paint film in this way, apparently hardening by taking up oxygen from the air.

Rubberlike Natural Products

In addition to the rubbery materials obtained from plants other than Hevea, certain gums with properties only slightly resembling those of true rubber are used commercially. These gums are sold as *balata* and *gutta-percha,* and, while not as important as they once were, they go to industry in limited amounts.

Balata is produced largely in the northernmost regions of South America. It is made by drying the juice of several species of trees, members of the Sapotaceae, and compressing the coagulum into sheets or blocks. Gutta-percha is derived from other trees of the same family, but is obtained from the leaves of the trees by crushing them, cooking out the rubbery constituent, collecting and compressing into blocks.

Gutta-percha is produced on several plantations in Malaya and Java, and the jungle gum has disappeared from the market.

Balata and gutta-percha are hard, hornlike substances when cold, but are extremely tough. They soften upon heating, and at about 212 F are rather sticky, plastic, and capable of being molded. Cooling causes it to return to its original hornlike state, and the process may be repeated indefinitely.

The gum resists most petroleum solvents, such as naphtha, when cold, but dissolves when hot; is readily soluble in most aromatic hydrocarbon solvents; chlorinated solvents dissolve it readily. It oxidizes easily, especially when in solution. It is quite resistant to hydrofluoric acid, and gutta-percha bottles have been used to store this acid. Sulfuric and nitric acids attack it, but alkalies do not. When the gum is pure, water absorption is extremely low, a point that dictated its use as an insulation in the early submarine cables. It also possesses excellent aging properties.

Gutta-percha is still used for golf balls, for vessels or linings of vessels to contain hydrofluoric acid, for the production of thin sheets of surgical material, for certain types of water-resistant packings, and for dental stoppings.

Synthetic Rubbers

Although it is inaccurate, the term "synthetic rubber" has become current for designating several synthetic elastomers of great importance industrially. It is a tribute to the usefulness of rubber that all of the great world powers among the nations have found it a military necessity to assure themselves of an adequate supply of rubber itself, or of satisfactory synthetic substitutes. While research has produced dozens of materials of a "rubbery" nature, only a few have achieved commercial success. During the war, manufacture of these was expanded so greatly that the production of synthetic rubber was able to supply the military needs of this country, part of those of our allies, and the essential civilian needs of the United States as well. Since the war part of this manufacturing capacity for synthetic rubber has been kept in operation as a national defense measure by demanding that rubber manufacturers use certain percentages of synthetic rubber in such articles as rubber tires. As manufacture of automobile tires takes about 70% of the tonnage of rubber used in this country, a regulation that tires shall contain fixed percentages of synthetic rubber is sufficient to force continued synthetic production.

Aside from military necessity, the synthetics had established themselves in the industrial market before the war, by virtue of superior properties over natural rubber, especially in oil resistance, better aging properties, and resistance to deterioration by heat and light. These special properties will be considered in connection with each of the commercially important types of synthetic rubber.

In studying the synthetic rubbers, the importance of the chemical composition butadiene is immediately apparent. When research chemists failed to duplicate the polymer of isoprene that is natural rubber, they turned to butadiene, for which raw materials were easily available. Three of the leading classes of synthetics are based upon this composition, and it is a minor ingredient in a fourth.

Butadiene-Styrene Copolymers—Practically all of the synthetic of this type now being produced is made in plants owned by Government Rubber Reserve. From its origin and composition, it is usually designated GR-S. The same general type of synthetic, made with metallic sodium as a catalyst, was called Buna-S by the Germans in the years immediately preceding the war; the name combined butadiene, natrium (sodium), and styrene in its composition. Inasmuch as catalysis with sodium is now regarded as obsolete, the designation "Buna-S" is no longer appropriate to the present synthetics of the butadiene-styrene type.

This type of synthetic was selected for the major part of the government's wartime program for rubber, and it is now one of the leading synthetics in point of availability. It is quite similar to natural rubber in processing, and resembles it rather closely in properties also. Like rubber, its strength is improved by compounding with carbon black. It is compatible with natural rubber, and, because of inferior properties in the pure gum stock, is practically always compounded with natural rubber or other gums.

Vulcanizates are produced by treatment with sulfur and accelerators, as with natural rubber. It may be cured to hard rubber also.

Butadiene-styrene rubbers are slightly superior to natural rubber in aging properties, but possess no advantage in oil resistance, nor in resistance to oxidizing agents, aromatic solvents, and chlorinated solvents. It may partially replace rubber in most applications.

Electrical properties of the butadiene-styrene synthetics compare closely to those of natural rubber. Resistance to water absorption is a little better than that of natural rubber, so electrical properties are maintained well.

Resistance to deterioration by heat is slightly better than that of natural rubber.

These synthetics will probably be the general-purpose substitutes for natural rubber in peacetime, with sufficient production maintained regardless of the slight price advantage of the natural material. National defense will probably make it necessary to continue producing a substantial tonnage of the synthetic, even if it must be subsidized permanently. It does not possess any outstanding advantages in properties over natural rubber, so cannot qualify as a specialty material.

Butadiene-Acrylonitrile Copolymers— A type of synthetic rubber differing from the natural article more than does the preceding class, but still having many points of resemblance, includes the copolymers of butadiene with acrylonitrile. The Rubber Reserve designation for this group was GR-A, to indicate the presence of acrylonitrile as the copolymer. The German product was called Buna-N, the "N" indicating that the nitrile entered the composition instead of styrene. The "GR-A" designation is now no longer used, and the German name does not properly represent today's material.

The acrylonitrile rubbers are true specialties, as they possess definite advantages over natural rubber that would insure their manufacture if nature's product were available in unlimited quantities. One of the outstanding advantages is in definitely greater resistance to deterioration by oils. They are used, usually in combination with some natural rubber, for oil and gasoline hose, printers' blankets, gaskets, packings, tank linings, etc.

Acrylonitriles are capable of being vulcanized with sulfur and accelerators, and can be cured to hard rubber. They are somewhat more difficult to process then natural rubber, however.

Although they possess good resistance to water absorption, the acrylonitriles undergo deterioration in sunlight. Resistance to ozone is better than that for natural rubber, but it possesses poorer resistance to cold, and slightly better resistance to heat. Its resistance to most organic solvents is superior to that for natural rubber. It is stronger than the styrene rubbers, but not as strong as natural rubber.

Electrical properties are slightly inferior to those of tree rubber. Heat resistance is somewhat better.

Acrylonitrile rubbers are compatible with natural rubber and with many other substances, such as plastics. They have won a place for themselves as blending materials, especially in combination with phenolics and vinyls among the plastics.

Chlorobutadiene Polymers—Synthetics of this type, usually called chloroprenes, have the distinction of being the first commercially successful synthetic rubbers. It was first offered to industry by the du Pont Company in 1932. Their product is now familiar under the name of Neoprene. The government-sponsored product was called GR-M, the "M" being derived from its chemical building block, monovinyl acetylene.

The synthetic rubbers as here given have shown progressively less resemblance to natural rubber. With the chlorobutadienes, oil resistance becomes higher, heat and light resistance are increased, and chemical resistance in general is better. They are not vulcanizable with sulfur, though curing by other means is possible. They cannot be

cured to hard rubber, however.

These chloroprenes cannot be milled to plasticity, as is the case with natural rubber, and to a less extent with the two preceding types of synthetics, without first adding chemical plasticizers. The material tends to heat-cure during the milling otherwise, so that the stock stiffens on the rolls instead of becoming plastic.

Resistance to swelling and deterioration in petroleum oils, to aging, to deterioration by heat, sunlight, ozone, and to attack by most chemicals are the characteristics that have made the chloroprenes important specialties. They possess the best light resistance of any of the rubbers. The material is one of the standards for oil-resistant hose; for gaskets that must possess good properties at slightly elevated temperatures or resist attack by lubricating oils; for conveyor belts that must carry warm or oily pieces; for barrage balloons, where flame resistance is important; for the outer sheath of electrical insulation that must have good flame resistance; for heavy-duty tires, and for oil-resistant footwear.

Electrical properties are inferior to those of natural rubber, but are adequate for most purposes.

Isobutylene Copolymers—Isobutylene may be polymerized with small quantities of butadiene or isoprene to produce a synthetic rubber that closely resembles natural rubber in many of its properties. As raw materials, obtainable from petroleum, are cheap and plentiful, and manufacturing costs are low, these synthetics are likely to be one of the important types for general-purpose replacement of natural rubber.

Commonly called "butyl" rubber, the designation for the government-sponsored material was GR-I. Butyl rubber is an American development, with the laboratories of Standard Oil of New Jersey pioneering.

Butyl rubber resembles natural rubber in its processing characteristics. It may be milled with the help of plasticizers, and can be vulcanized with sulfur and accelerators. It requires a much longer curing time than natural rubber, however, and cannot be cured to hard rubber.

One of the outstanding characteristics of butyl rubber is its low permeability to gases. This makes it of value for inner tubes in tires, and also for wartime use in gas masks and other protective devices. It possesses good resistance to aging, and to sunlight, ozone, and acid attack; heat resistance is superior to that of natural rubber. Its most annoying disadvantages are its low strength and its susceptibility to cold flow. It will burn rather readily. Abrasion resistance is poor, also.

Polysulfide Rubbers—Least like natural rubber, and resembling some of the elastomeric plastics such as the vinyls, are several synthetics with interesting special properties. They are offered under the trade name Thiokol, though this same name, with appropriate letter designation, is used to indicate other types of synthetic rubbers also.

The polysulfide rubbers stand at the top of the list in oil resistance, and are used to make oil hose and similar equipment for refineries and the oilfields. Their chemical resistance generally is high, but strength properties, resistance to cold flow, resistance to abrasion, and resistance to elevated temperatures are poor. They are lacking in resilience, but are used for gaskets and packings where oil or chemical resistance is the determining factor.

Processing is more difficult than for natural rubber, or for the other synthetics in general.

Polyacrylates—A new class of synthetic rubbers, the polyacrylates offer interesting properties at elevated temperatures, oil resistance, and good processing properties. They will undergo long-time exposure to temperatures of about 400 F with little deterioration, yet are compatible with natural rubber. They can be vulcanized, and possess good strength properties. The working temperature limits are about 250 F for continuous exposure, 400 F for intermittent service.

Materials of this sort have been used in adhesives for several years, but they are new as synthetic rubbers. Ethyl acrylate has served as an adhesive for pressure-sensitive tapes particularly. Copolymerized with small amounts of other chemicals, it promises to become important as a synthetic for use at elevated temperatures. Gaskets, electric wire insulation, brake linings, etc., are proposed uses.

It possesses excellent resistance to ozone and to sunlight, and has been suggested as a coating for textiles and paper.

Silicone Rubbers—A group of elastomers having no chemical resemblance to natural rubber, but included here because they are used as rubbers, are those unusual compounds, the silicones. The silicones include liquids, pastes, and solids, but the elastomeric compounds are several having a siloxane linkage and many of the properties of the rubbers.

Because they are not built with a carbon linkage, as are natural and synthetic rubbers, the silicone rubbers are not subject to the temperature limitations of the organic rubbers. The silicon-oxygen-silicon linkage permits working temperatures to be carried to about 300 to 350 F for continuous service, and to about 500 F for intermittent. When overheated, silicones become brittle and may give off vapor. They retain their elasticity at temperatures of −70 to −100 F.

Silicone rubbers are not compatible with natural rubber, nor with the other synthetics. They are compounded with mineral fillers when the application makes this desirable, but the compounding is done by the original producer. They can be cured also, by heating with a vulcanizing agent, but the vulcanizing agent is added by the manufacturer to those types for which it is suitable.

The vulcanizing and curing process is different from that for natural rubbers or the other synthetics. The complete process is:

(1)—Vulcanizing—done in a press or autoclave with the properly compounded silicone rubber. Heating at 260 F for 3 to 5 min., depending upon the size of the piece, is the recommended procedure.

(2)—Precuring—effects the release of gases. The temperature schedule may start at about 175 F, for about 2 hr.; then to about 230 F, for 1 hr.; then to about 390 F, for 4 hr. This schedule, while not valid for all compositions, is typical of many.

(3)—Final cure—a temperature of about 480 F is maintained for from 4 to 24 hr., the shorter heating time giving an article of lower strength but greater elasticity, the longer period developing greater strength and a harder material.

Silicone rubbers are highly resistant to water and petroleum oils, but tend to swell when exposed to the aromatic solvents. Carbon tetrachloride, perchlornaphthalene, and occasionally other solvents are used with silicone rubbers for dip or spray coatings. The material applied by dip or spray has good adhesion to iron or steel, fair adhesion to copper, and poor to aluminum or magnesium. For coating metals to which silicone rubbers do not ordinarily bond well, the metal can be sprayed with a solution of another silicone, the film dried, cured at 480 F for 30 min., and then coated with the silicone rubber.

Natural rubber and the other synthetics can be solvent bonded to themselves, and can be joined to many other substances by use of the proper adhesives. There are no adhesives for the silicones, and solvent bonding cannot be accomplished. The silicone rubbers swell in suitable solvents, but do not bond. Bonding of uncured pieces, or of cured to uncured pieces, may be done by heat and pressure, as in curing. Cured pieces will not bond to other cured pieces by this method.

Because of their high cost, the silicone rubbers are strictly specialty materials. They are assured of a market because they afford a unique combination of resilience with high- and low-temperature working ranges, and with resistance to attack by most chemicals. They are sold as molding compounds, calking and sealing stocks, and paste stocks for coating. Some of their most important uses have been in high-temperature gaskets, such as those in gas turbines and jet aircraft; high-temperature covering for electrical conductors, conveyors for warm castings and heat-treated parts, etc.

Acknowledgment

We hereby acknowledge the technical assistance provided by the following companies:

Bakelite Corp., New York City
Dow-Corning Corp., Midland, Mich.
Firestone Rubber Co., Akron, Ohio
General Electric Co., Pittsfield, Mass.
B. F. Goodrich Co., Akron, Ohio.
B. F. Goodrich Chemical Co., Cleveland, Ohio
Goodyear Tire & Rubber Co., Akron, Ohio
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Enjay Co., Inc., New York City
Thiokol Corp., Trenton, N. J.
U. S. Office of Rubber Reserve, Washington, D. C.
U. S. Rubber Co., New York City

MATERIALS & METHODS Engineering File Facts

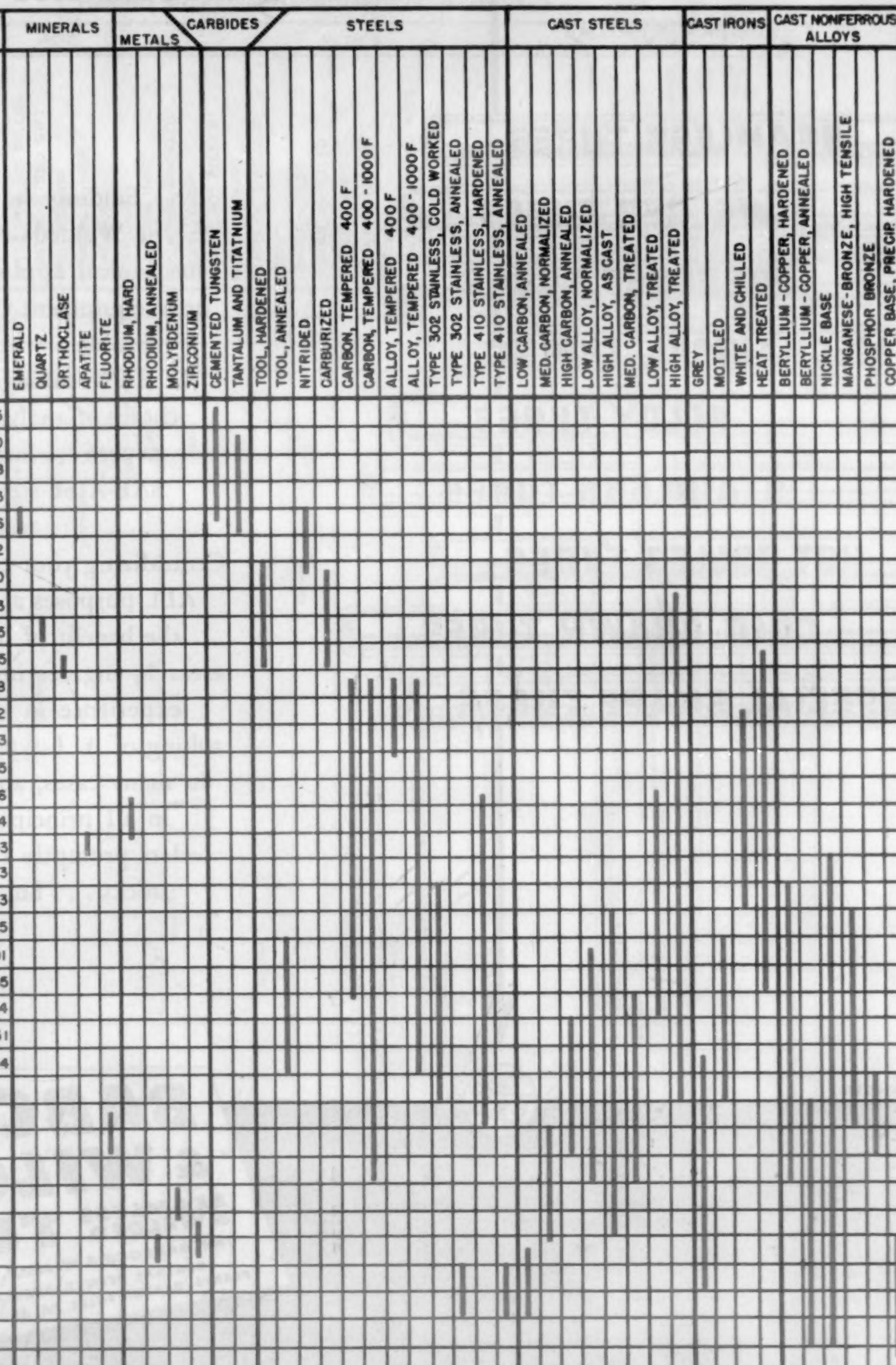
NUMBER 160
May, 1948

MATERIALS: General

HARDNESS RANGES FOR VARIOUS MATERIALS

HARDNESS

MOH	ROCKWELL B	BRINELL 500 KG	BRINELL 3000 KG	ROCKWELL C	VICKERS
				80	1865
8				78	1710
				75	1478
				73	1323
				70	1076
				68	942
7				65	820
				63	763
			614	60	695
			587	58	655
6			547	55	598
			522	53	562
			484	50	513
			460	48	485
			426	45	446
			404	43	424
			372	40	393
5			352	38	373
			322	35	343
			305	33	325
			283	30	301
			270	28	285
			255	25	264
		206	245	23	251
	98	189	228	20	234
	96	179	216		
	94	171	205		
	92	163	195		
	90	157	185		
4	88	151	176		
	85	142	165		
	81	133	153		
	78	126	144		
	74	118	135		
	70	110	125		



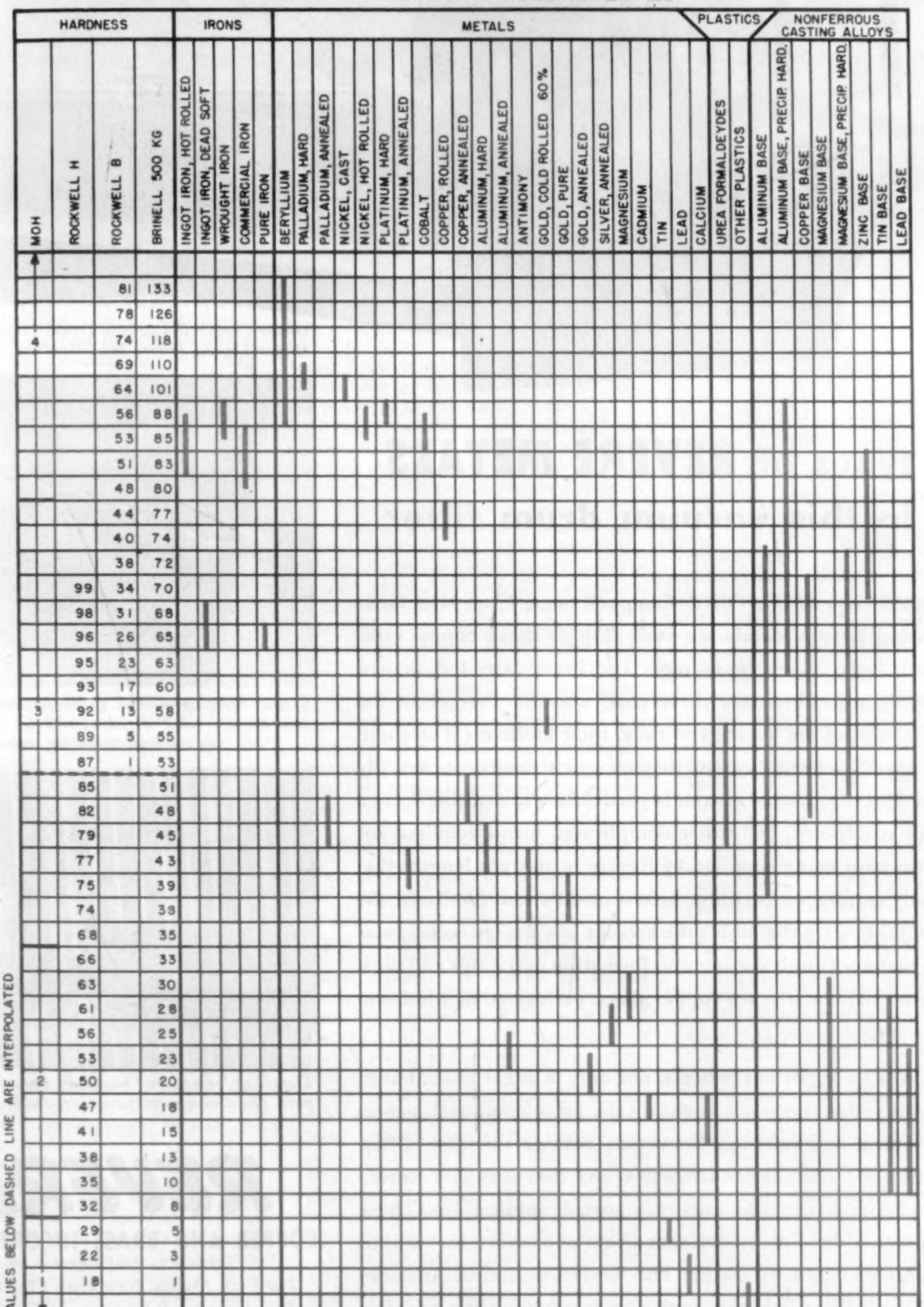
COMPILED BY S D. SMOKE DATA BASED ON THE PURDUE UNIVERSITY CHART, "VICKERS, ROCKWELL AND BRINELL HARDNESS VALUES FOR VARIOUS MATERIALS AND ALLOYS" BY J T AGNEW, NOW RESEARCH ENGINEER, THE FRANKLIN INSTITUTE

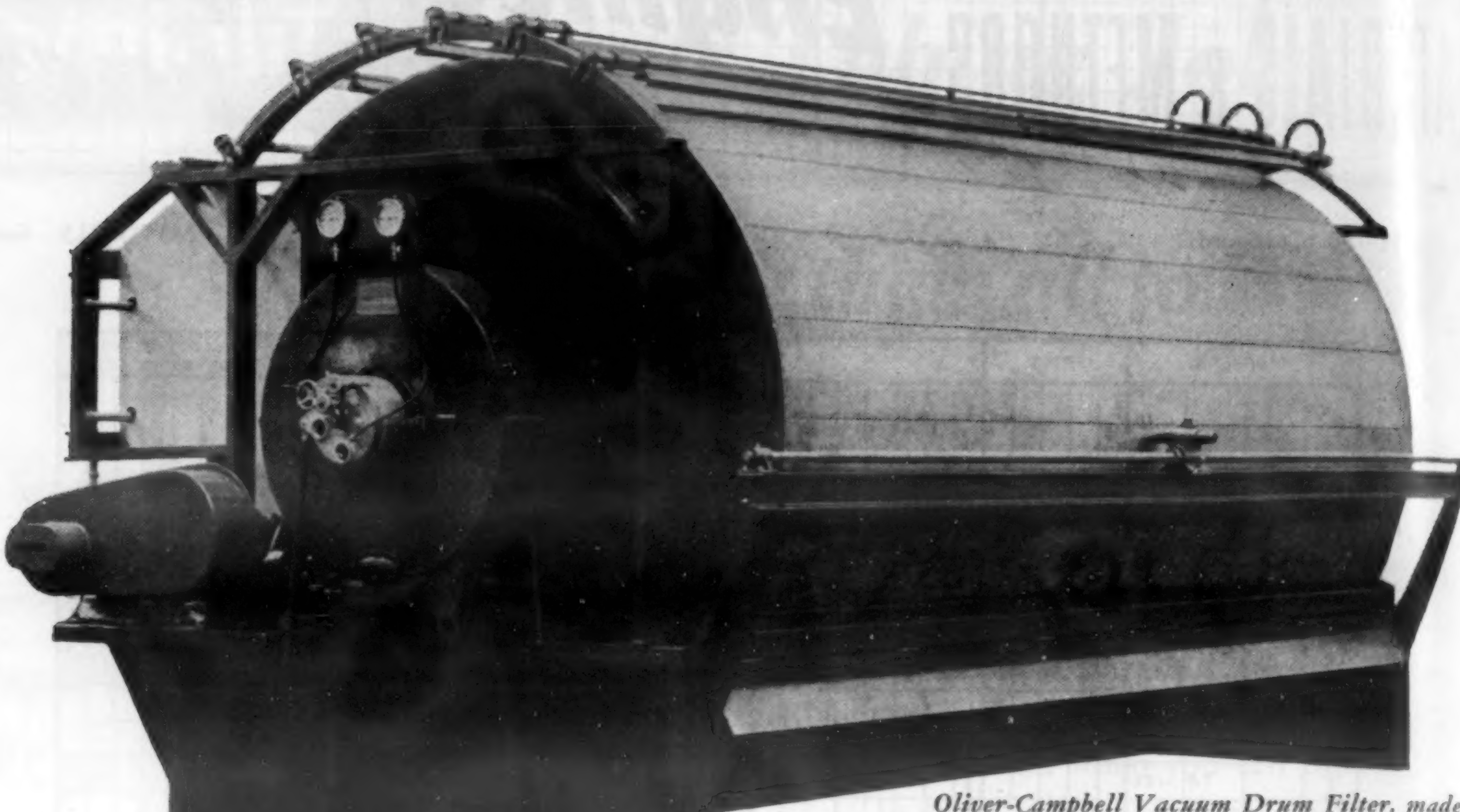
(Continued on page 107)

NUMBER 160 *(Continued)*

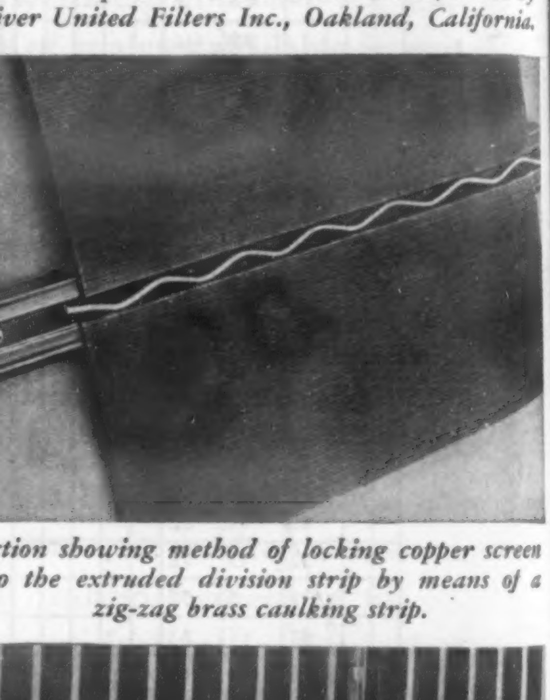
MATERIALS: General

HARDNESS RANGES FOR VARIOUS MATERIALS

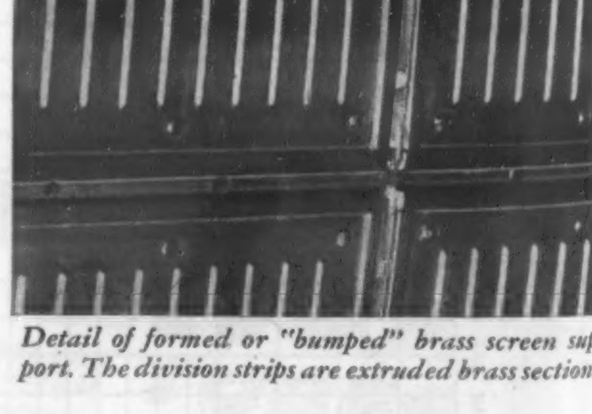




Oliver-Campbell Vacuum Drum Filter, made by Oliver United Filters Inc., Oakland, California.



Section showing method of locking copper screen into the extruded division strip by means of a zig-zag brass caulking strip.



Detail of formed or "bumped" brass screen support. The division strips are extruded brass sections.

6 types of REVERE METALS in this vacuum drum filter

In the manufacture of this Oliver-Campbell Sugar Cane Mud Filter the following Revere Metals are used: Copper sheet, copper tube, brass sheet, brass discs, brass pipe, and brass extruded shapes. These metals are chosen for three chief reasons: they resist the corrosive action of the filtrate and cake, their mechanical strength is such as to assure durability, and they are quickly and economically fabricated. Use of extruded shapes is particularly interesting from a fabrication standpoint, the rather complicated forms required for the division strip being supplied by Revere in straight lengths that require only cutting and drilling before installation. Similarly, the zig-zag caulking strip that holds the screens is a Revere rectangular extrusion that needs only cutting plus formation of the zigs and zags. The screens, incidentally, are copper sheet, perforated 625 holes to the square inch.

Filtration is an important process, not only in sugar mills, but in a great many industries, such as chemicals, petroleum, coal, paper, cement, mining and refining, breweries, sewage disposal. Often both filtrates and sludges are corrosive, and thus it is that Revere Copper and copper alloys find many important applications. These metals are available in many different alloys and forms, resistant to a wide range of corrosive media. The Revere Technical Advisory Service will gladly collaborate with you in studying the problem of corrosion in your plant equipment or product.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere

MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Pressure Welding of Light Alloy Bar

Pressure welding of metals in the solid phase is still a relatively new process, and its application to light alloys has been fairly limited. R. F. Tylecote in *Sheet Metal Industries* (English), Jan. and Feb., 1948, says that pressure welding is particularly well suited to this field. It can make high quality welds on large and small areas with moderate thicknesses where flash welding, on the other hand, requires very high currents and expensive equipment.

Unlike flash welding, there is no fused zone in pressure welds, so the full benefit of heat treatment is attainable after welding. Weld strengths about 80% the strength of the original material are possible in pressure welded bars tested in tension. The reason this value is not better is presumably due to the presence of oxide in the joint and, in some cases, to grain coarsening. The unavoidable oxide is probably also the cause of the low elongation as-welded. A non-heat treatable aluminum-manganese and an aluminum—7% magnesium alloy appear to give the highest weld efficiency and the best elongation values of a number of light alloys tested.

Pressure welding has certain disadvantages. If the thickness is over about ½ in., there is an appreciable temperature gradient between the outside and center. Also, the presence and consequent need for removal of the upset material is a difficulty. While the upset material is likely to be larger than the flash in flash welding, the weld contour of the former is better.

The upset material could probably be left in position in tubes, but in sections and ornamental moldings it would have to be machined off after welding. An alternative method would be to machine the material to a cone shape before welding so that the upset would compensate for the material removed.

Recent Advances in Powder Metallurgy

Four papers and a seminar of unusual current interest were presented at the powder metallurgy session during the last annual meeting of the American Institute of Mining & Metallurgical Engineers. These papers are indicative of the rapid advances being made in this expanding field of metal parts production.

Nickel Steels by Powder Metallurgy

In recent years the question often has been asked: what is the effect of alloying elements on the properties of iron compacts? The paper by L. Delisle & W. V. Knopp ("Nickel-Steels by Powder Metallurgy") contributes an answer. The aim of their work was the preparation of nickel steels from elemental metal powders. The composition of the steels used were those of S.A.E. 2330 and S.A.E. 2340.

It was found that despite prolonged sintering, diffusion of the nickel and other alloying elements in the solid state was not completed. However, a marked change in the properties of the steel were observed even with only part diffusion. For example, a steel containing 3.5 nickel and 0.23% carbon, sintered at 2410 F, gave a tensile strength of 142,000 psi. and an elongation of 3% after quenching in oil and tempering. Addition of manganese and silicon in the amounts present in the usual S.A.E. 2330 produced an additional increase.

Other nickel contents were investigated in hopes of obtaining a steel that would have moderately high hardness without heat treatment. It is possible that inhomogeneous alloys as those produced in these tests may find applications where homogeneous steels are unsatisfactory.

Powdered Metals with Controlled Porosity

A unique approach to the high temperature materials consists of making high temperature parts of a porous material so that a cooling fluid can be forced through the pores. This method is referred to as "sweat cooling." A method of making porous metals and alloys for such applications was described by P. Duwez & H. E. Martens ("The Powder Metallurgy of Porous Metals and Alloys Having a Controlled Porosity").

The method consists essentially of mixing a porosity-producing substance with the metal powder, pressing the mixture, and sintering. During heating, but before sintering, the porosity-producing substance dissociates and creates the porosity. Ammonium bicarbonate was used, but other substances might give equivalent results.

Using this method porous stainless steel (type 302) and porous nickel-molybdenum-iron alloy were prepared. The physical properties of these alloys are discussed in the paper.

Magnetic Properties of Iron-Powder Compacts

In a paper by R. Steinitz ("Magnetic Properties of Iron-Powder Compacts") the results of a systematic experimental study of the relationship between magnetic properties and densities of iron compacts was presented. Measurements were made to determine the permeability of soft iron compacts for different densities and raw materials, and it was found that the raw material has a negligible influence on the magnetic properties if these are compared for identical densities, and not for identical processing procedures.

Fabricating Properties of Iron Powder

As the field of application for iron powder parts widens, greater demands are made upon the powder supplier concerning quality and uniformity characteristics. Methods for evaluation of the molding, coining, and sintering properties were presented in a paper by J. F. Kuzmick ("Evaluation of the Molding, Coining and Sintering Properties of Iron Powder"). The results obtained by the application of these methods to one grade of Swedish iron powder were given in some detail as an example.

Sintering in the Presence of a Liquid Phase

The seminar on sintering in the presence of a liquid phase, conducted by F. V. Lenel, was much too lengthy to do justice to here, and only the scope can be indicated. Two mechanisms of sintering were covered. In the first the liquid is present during the entire time while the compacts are at the sintering temperature. In the second the liquid phase is formed during the sintering process, but disappears before the sintering is completed through diffusion and formation of a solid solution. Throughout the seminar emphasis was laid upon the microstructural and density changes during sintering. Other physical and mechanical properties of sintered compacts were also discussed.

DIGEST

Zinc-Base Bearings

Zinc-base bearings represent a new bearing material which is more than a substitute and, therefore, should receive engineering attention in the United States, according to a report on German research on zinc-base bearings issued by the Office of Technical Services, Department of Commerce, ("German Research on Zinc-Base Bearings," PB-42654).

The report by F. R. Hensel & W. M. Pollitzer points out that zinc-base bearings have applications in electric motors, driving rods, coupling rods and axles of narrow-gage locomotives, and as bearings for street cars, traveling wheels and transmissions of cranes and in crushers and harvesting machinery. In addition, the fine zinc alloys proved excellent as main bearings as well as driving unit and auxiliary bearings for machine tools and wrist-pin bushings in small Diesel engines.

Compared with red brass, tin bronze, white metal with high tin contents, and lead-base bearing alloys with a low content of tin, the zinc alloys are superior in tensile and fatigue strength, and in hardness. The zinc alloys are superior to the standard bearing materials in respect to thermal conductivity; the coefficient of thermal expansion is higher than that of conventional bearing alloys. Zinc alloys can be used as solid bearings due to their high tensile strength at low temperatures, the report states.

Aircraft Materials Developments

The thirty-third annual report of the National Advisory Committee for Aeronautics, recently issued, is a valuable document because it brings together in one place the results of a wide variety of developmental projects which, although directly concerned with aircraft, are also related to many other fields. Here, given briefly, are a few of the findings of specific interest to materials engineers.

High Temperature Materials

In a comprehensive investigation of turbine disk forgings, sheet and cast materials, all the results show that the effects of heat treatment and other processing variables can influence the physical properties of the alloys more than changes in composition.

In the field of ceramics, refractory coatings have been found effective in protecting molybdenum metal instrument probes in

DIGEST

ram-jet engines. Despite molybdenum's high melting point of around 4700 F, it cannot be used at elevated temperatures without protection from oxidation.

An investigation of the tensile properties of a sillimanite refractory material revealed that its strength-density ratio compared very favorably with that of high-temperature metals. It was also found that the tensile strength actually increased at high temperature. Using this material for turbine wheels, operating temperatures of 1725 F at a tip speed of 520 ft. per sec. were successfully attained.

Magnesium-Cerium Forging Alloys

While magnesium-cerium forging alloys have not been widely used in the past, available data indicate that these alloys in the wrought condition possess an unusual combination of low density and relatively high mechanical properties for service up to at least 600 F. Tests were conducted to improve the elevated temperature tensile properties and resistance to creep of these alloys.

Fracture of Metals

As higher strength materials are used in order to provide lighter weight structures, it becomes increasingly important to have detailed knowledge of the factors affecting their fracture strength. The investigations on this subject completed during the past year include the following: Tests on the effects of circumferential notches on the fracture characteristics of 24S-T aluminum alloy revealed that for mildly notched bars the fracture stress increased with increasing transverse tension, while ductility decreased correspondingly. In another series of tests, the mechanical properties and plastic stress-strain relations of 24S-T subjected to biaxial stresses were determined.

A series of investigations was also conducted on 75S-T aluminum alloy. In tests on the effect of combined stresses on the fracture strength, it was found that the alloy ruptures in substantial agreement with the critical shear stress law for fracture. In an investigation to determine the relationship between stresses and plastic strains of wrought aluminum alloys under tension, compression and torsion loadings, it was found that universal stress-strain curves as predicted by the theory were not obtained. Fair correlation between the theory and experimental facts, however, was obtained with a cast and solution heat-treated magnesium alloy which behaved isotropically during plastic deformation.

Nonmetallic Materials

A knowledge of the effects of tempera-

DIGEST

ture on the strength properties of laminated plastics is important because in high-speed flight applications the surface temperature increases with increasing speed. During the past year tests have provided information on the Izod impact, flexural properties, tensile and compressive properties in the temperature range from −70 to 200 F on laminated plastics containing as the reinforcement glass, asbestos, rayon and cotton fabrics, and high strength paper.

As the result of an investigation on sandwich materials it was found that the compressive and tensile strength of resin-impregnated paper honeycomb structures are lower than those of balsa wood, and that the modulus of rigidity, shear stress at proportional limit, and shear strength compare favorably with corresponding properties of balsa wood.

Heat Treating Developments

Among the technical papers on the subject of heat treating presented at the February meeting of the American Institute of Mining & Metallurgical Engineers, three in particular contain results of practical significance.

Notch Properties of Low Alloy Steel

One of these, by G. Sachs, L. J. Ebert & W. F. Brown, studies certain strength properties of a partially austempered and subsequently quench low alloy steel, namely, in SAE 5140 chromium steel ("Notch-Tensile Characteristics of a Partially Austempered, Low Alloy Steel"). The data clearly show that very small quantities of intermediate products when present in a matrix of hard martensite are a potent embrittling factor.

In some low alloy steels, such as SAE 5140, the formation of these products may be very difficult to avoid using conventional quenching. Thus, a slight delay in quenching or too large a section size may result in a portion of the section containing small amounts of ferrite and/or intermediate products.

A few tests on specimens austempered at 950 F for various lengths of time and then tempered for 1 hr. at 950 F indicate that a mixed structure tempered at a sufficiently high temperature possesses approximately the same notch properties as a pure tempered martensite of the same hardness.

Anisothermal Decomposition of Austenite

Both hardenability and practical heat treatment of steel involve anisothermal de-

DIGEST

composition of austenite. In his paper ("Anisothermal Formation of Bainite and Proeutectoid Constituents in Steel"), L. D. Jaffe arrives at some practical conclusions based on studies in which only a small amount of anisothermal transformation of austenite occurs. Thus, he has found that the conditions for 1% transformation of austenite by the proeutectoid reactions under any conditions of temperature and time, including continuous cooling, can be calculated from isothermal data. In addition, it is predicted that delaying the quench of a hypoeutectoid steel until it is below the A_{e3} temperature will effectively decrease its bainitic hardenability, while delaying the quench until it is below the A_{cm} temperature will effectively increase its bainitic hardenability. Finally, it was found that for a fixed rate of cooling, increases in molybdenum content and grain size reduce the fractional time in the proeutectoid ferrite range; this reduction, in turn, increases the time necessary for subsequent formation of small percentages of bainite.

Evaluation of Quenching Oils

The evaluation of quenching oils by use of the end quench test was described by C. A. Siebert ("An Evaluation of Quenching Oils by Means of the End Quench Test"). Five commercial oils were investigated and the results are given in the paper. It was found that increasing the flow of the oil caused an increase in the hardening power, while an increase in temperature of the oil resulted in a decrease in the hardening power. Also, with high rates of agitation, such as those encountered in these tests, there is little, if any, advantage gained by using a propietary compounded oil in place of a straight mineral oil.

Plating on Zinc Die Casting

Since electroplating is a widely used method for finishing zinc-base alloy die castings, means of achieving better platings are constantly being sought. A symposium in *Plating*, February 1948, and a paper in *Metal Industry*, an English publication, report on some of the latest developments.

One of the articles in the symposium by M. R. Cladwell ("Recent Developments in the Finishing of Zinc-Base Alloy Die Castings") points out that where nickel plating is concerned the industry is still not in agreement as to the minimum depth of copper and the total depth of copper plus nickel required to withstand outside weather

DIGEST

conditions. Based on data collected by the author, it is concluded that parts subject to mild exposure require 0.0002 in. of copper and 0.0003 in. of nickel, for a total of 0.0005 in. However, parts subjected to severe exposure, such as outside automobile hardware, are being plated with a total depth of plate of 0.0008 to 0.0015 in., depending upon the part and the expected life.

The problem of plating porous areas in zinc die castings is an ever present one. It was found that such areas were definitely improved by polishing, and in these specific tests the average amount of metal removed was 0.0006 in.

Bronze as an Undercoat for Nickel Plating

Copper and brass are, at present, standard undercoatings for bright nickel plating on zinc die castings. Recent investigations reported by P. Berger in *Metal Industry*, Jan. 30 and Feb. 13, 1948, indicated that electrodeposited bronze might be better than either. It is known that metallic zinc reacts with copper and brass even at room temperature. Therefore, copper deposits tend to be absorbed by the zinc while brass slowly diffuses into the underlying zinc. In either case, an alloy layer is formed which segregates from the basis metal. Consequently, the thickness of the copper or brass must be sufficient to last for the life of the part. In this respect, the bronze appears to have an important advantage in that it is absorbed only slowly by zinc-base alloys.

A deposit of as little as 0.00015 in. of bronze will give the same results as double that thickness of copper. The bronze deposit is also entirely nonporous, so the nickel solution is protected against zinc contamination.

Obtaining High Quality Platings

All the various factors involved in getting a high quality plating on zinc die castings are taken up in two papers of the symposium—one by E. A. Anderson & C. E. Reinhard ("Causes of Failure of Plated Coatings in Automotive Service"), and the other by R. M. Wagner ("Plating of Zinc-Base Alloy Die Castings"). Perhaps the most important single factor in service performance is coating thickness. Increased thickness of coating can often compensate for other deficiencies, but there is no way of compensating for insufficient thickness.

Another very important factor is adhesion. Good adhesion depends to a large extent on the processes preceding actual plating, such as alloying and casting practice, polishing, and cleaning.

And finally, R. F. Burns lists some design tips which can save the electroplater

DIGEST

many troublesome pitfalls in finishing ("Sound Zinc-Base Alloy Die Castings"). Here are a few: (1) A bead at the die parting minimizes somewhat the problem of removal of the flash and the scarring of the casting by tool marks; (2) sharp corners should always be avoided because they are points of structural weaknesses and are difficult to buff or polish; (3) plain, flat surfaces should be avoided because such surfaces magnify any imperfection; and (4) deep recesses should be avoided and generous radii on curved surfaces should be provided.

Ferroalloys Degassed in Solid State by Vacuum Techniques

War-time progress in vacuum techniques has led to a search for suitable commercial methods for degassing ferroalloys. Degassification in the solid state is promising as it does not involve complicated melting equipment. The ferroalloys, however, must be in a finely divided form to permit diffusion of the gas in a reasonable time. In *Revue de Métallurgie* (French), May-June, 1947, J. Hochmann describes an investigation on a number of ferroalloys.

Mond nickel, electrolytic nickel, cobalt, chromium, ferrochromium, manganese, ferrosilicon, ferrotungsten, ferromolybdenum, aluminum, ferrovanadium, ferrotitanium and ferrocolumbium were vacuum treated at 1110 to 2550 F, although each was not tested over the entire temperature range. A substantial removal of hydrogen was obtained with all but aluminum and ferrovanadium.

The amount of CO and CO_2 evolved varied widely, with a particularly large amount observed for the cobalt. The removal of nitrogen was incomplete in the ferrosilicon and ferromolybdenum. Practically no nitrogen was evolved from ferrovanadium, ferrotitanium, aluminum and ferrocolumbium, as might have been expected from the stability of their nitrides.

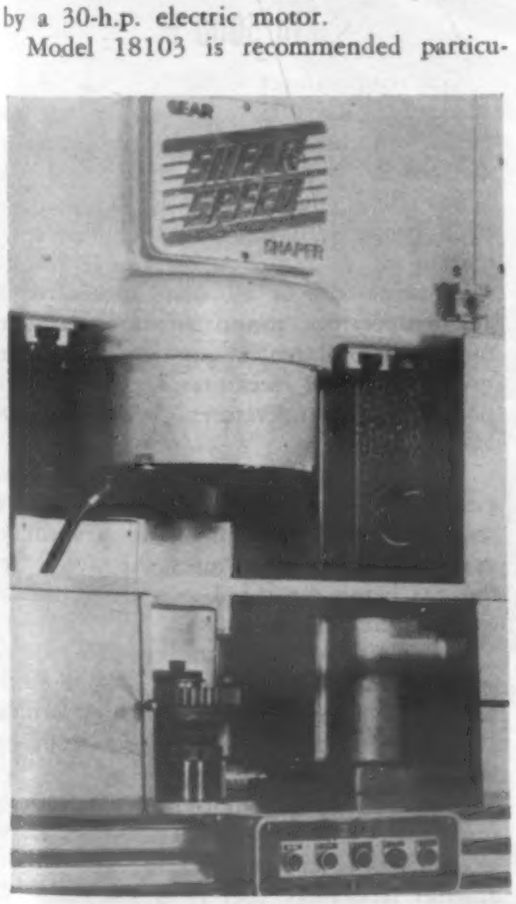
Degassing in the solid state appears to be a practical means of eliminating at least part of the gas from most ferroalloys and thus removing one possible source of unsound metal. An additional interesting possibility is the production of very low nitrogen, low carbon ferrochromium, since the carbon content of ferrochromium was lowered during the vacuum treatment, probably due to a reaction with the oxygen present in the ferroalloy.

New MATERIALS AND EQUIPMENT

External Shaper Cuts All Teeth in Gear Simultaneously

A larger model shaper capable of cutting all teeth in gears and other external shapes simultaneously has been added to the Shear-Speed line of *Michigan Tool Co.,* 7171 E. McNichols Rd., Detroit 12, Mich. Model 18103 cuts shapes up to 10-in. O.D. and 2¾-in. thick. With special liners, it will take work down to 5-in. O.D. Physically, the machine occupies a floor space of 86½ by 78½ in., and is 123 in. high; it has a maximum stroke of 3 in.; and is powered by a 30-h.p. electric motor.

Model 18103 is recommended particularly for gears or involute splines from 5 to 12 pitch but will also cut straight-sided splines, sliding clutches, rachets, inverted splines, and other external shapes. These products can be shaped individually, or in some cases, stacked and cut in multiple units.



The Model 18103 shaper has just cut simultaneously all 47 teeth of an 8-in. dia. gear in 52 sec.

The method of automatically locking the head in cutting position is a new feature of the 18103. Hydraulically actuated wedge pins provide instantaneous locking of the head when it is lowered into cutting position by engaging a similar angular wedge surface on the two outer extremities of the machine head. The angle of the wedge surface on both the pins and the corresponding wedge surface on the head allows locking in the desired cutting position with only a simple initial adjustment of the head top. This reduces to a minimum the time required for adjusting vertical cutting position.

Synthetic Hose Increases Flexible Tube Durability

Dependability and life of flexible tubing has been measurably increased as a result of an extensive research program conducted by engineers of the *Ronaflex Tubing Co., Inc.,* Packard Bldg., Philadelphia 2, Pa. Development of new Buna and Neoprene base synthetics has made the newly designed hose assembly possible. This hose has good resistance to high temperatures, pressures, vibration, internal and external corrosive solvents, and fumes.

Standard sizes range from ¼- to 2-in. I.D. Lengths run up to 200 ft. in the small dia. and 50 ft. in the larger dia. One-quarter in. tubing will stand burst pressures to 1000 psi., while larger sizes operate at proportionately lower pressures. It is not uncommon for tubing of this type to operate at temperatures as high as 300 F.

Although Ronaflex assemblies find widest use in the automotive field, they also find considerable application in the gas, chemical, power, finishing, petroleum, railroad and shipping industries.

Condenser Tubes Made from Cupro-Nickel Alloy

A new cupro-nickel condenser tube for installations where severe operating conditions are encountered can be obtained at a price comparable to aluminum brass it has been disclosed by *Revere Copper & Brass, Inc.,* 230 Park Ave., New York. Nominal composition of the new tube is 88.5 copper, 10 nickel, and 1.5% iron. The new cupro-nickel alloy was developed by the British Non-Ferrous Metals Research Association.

Under certain operating conditions cupro-nickel should afford added service and might prove more economical than either Admiralty or aluminum brass. Revere has had test installations of low cupro-nickels in operation for periods up to four years.

The new condenser tube is recommended particularly for marine and utility installations, encountering high velocities, high temperatures, brackish or salt water, and bad pollution. However, it is not subject to dezincification.

Improved Tool Grinder Has Several Advantages

Many improvements have been incorporated in the No. 2 Cutter and Tool Grinder, built by the *Cincinnati Milling Machine Co.*, Cincinnati 9, Ohio. Principal advantages are increased conveniences of operation and less routine service attention.

Grinding wheel spindle bearings are the pre-loaded precision anti-friction type, packed in grease for life-time lubrication. Dual hand table traverse knobs, traditionally located at the rear of the machine, are duplicated at the front. The operator now has table traverse control at every possible operating position. Vertical adjustment of the grinding wheel head has been increased 3 in. to a total of 10½ in. This increases versatility of the machine in grinding large cutters, especially those which are mounted on the Face Mill Grinding Attachment.

Electrical controls are built in a recessed compartment at the front of the machine. A disconnect switch, operated by the latch handle on the electrical compartment door, shuts off the current when the door is opened. Additional safety will result from use of a transformer unit included with the controls for shops operating on high voltages. The transformer reduces the voltage to 110 at the push-button station. Push buttons are also built-in. They consist of start and stop buttons for plain and universal machines; in addition, universal machines are equipped with a two-way switch for the cylindrical grinding attachment motor. Daily lubricating requirements have been greatly reduced. Nine separate lubrication points are now serviced by a built-in reservoir and plunger pump.

In addition to the wide variety of attachments available for these machines, two types of "wet" grinding attachments are now available. One is for cylindrical grinding operations. It incorporates a motor driven pump and tank unit, built into the machine base, and includes splash guards around the table and wheel. The other attachment, separate from the machine, is for carbide grinding operations.

A motor-driven coolant pump and tank, and an air suction pump, are combined into one unit. A thin stream of coolant directed at the wheel is disintegrated into tiny drops by the rapidly revolving wheel. Air suction returns the moisture to the tank, keeping the table and machine dry while the wheel and work are clean and cool.

All other features of the old Cincinnati No. 2 Cutter and Tool Grinder have been retained.

Principal advantages of this cutter and tool grinder are increased convenience of operation and less routine service attention.

Impact Press Operated by Air

An air operated press of the medium heavy type for assembling, flanging, marking, forming, riveting and similar fabrications has been announced by the *Bellows Co.*, 222 W. Market St., Akron, Ohio.

The new press uses a Bellows BM-10 integral valve air motor for compression of a heavy die type spring from which the ram force derived. Impact pressure can be regulated from a few ounces to the maximum of 6500 psi. The downstroke of the air motor is used to compress the heavy die type spring which rests directly on the ram and is held in place by a spring loaded trigger mechanism.

Compression of the spring for any desired impact pressure can be quickly and easily regulated by adjusting lock nuts on the threaded portion of the air motor piston rod. The spring is released automatically when the air motor piston rod is fully extended. The return stroke of the double acting air motor returns the ram to starting position, where it is automatically locked in position by the trigger mechanism.

The solid steel ram shaft has a maximum clearance of 13 7/16 in. and a maximum movement of 1¼ in. with a vertical adjustment of 12 in. Throat clearance from the center of the ram is 7 in. while the base width is 10 in.

Indicator Measures Gas Temperatures to 5000 F

Gas temperatures to 5000 F can be measured by Unit 263, a laboratory gas temperature indicator, made by the *Fairchild Camera & Instrument Corp.*, 88-06 Van Wyck Blvd., Jamaica 1, N. Y. Insertion of a probe into the gas stream and operation of a single control valve on the instrument case is all that is required to get temperature measurements. Accuracies of 1% are guaranteed up to 2000 F; reproducibility of measurements to 2% is possible at temperatures from 2000 to 5000 F.

The basic Fairchild pneumatic gas temperature system is the heart of this new instrument, this system being a form of gas thermometer that uses the density of the gas being measured as a direct indication of temperature.

Temperature probes of suitable metals are used for temperatures to 2300 F while water-cooled probes with iridium orifices are used for temperatures from 2300 to 5000 F.

The Unit 263 indicator is especially suited for use with gas turbines, turbo jets, ram jets, rockets and for general industrial laboratory use. It is also valuable for determining the applicability of the Fairchild temperature system for incorporation in specific control systems.

SEE HOW "THE NEW ARITHMETIC IN STEEL"* MAKES EVERY FOURTH PART A BONUS PART

*

N-A-X HIGH-TENSILE stretches production per ton. Its greater strength and corrosion resistance make it possible to design sections an average of 25% lighter. That means one extra product for every three you are now building.

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

N·A·X

HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
UNIT OF NATIONAL STEEL CORPORATION

Electronic Micrometer Measures Thin Materials Accurately

To fill the need for a lower-cost standard measuring instrument, *Carson Micrometer Corp.*, 2 E. Main St., Little Falls, N. J., has made the Model K Electronic Micrometer. The device makes possible precision thickness measurements under anvil and pressure conditions selected to suit the material being measured. Accuracy, sensitivity and repeatability are completely independent of the operator. No skill or special training is needed to read dimensions accurately to 20 millionths of an in. on fine wire, capacitor paper, rubber sheet, plastic films, metal strip and foil, felt, paint films, linoleum, cork, photographic film, textiles, gaskets, cathode sleeves and thin walled tubing.

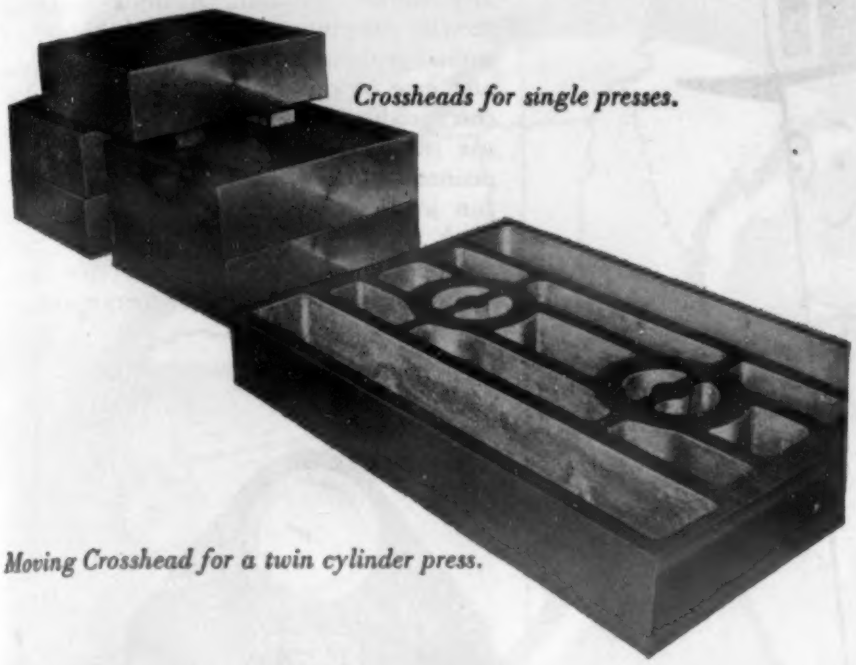
Measuring range of the Model K is 1/8 in., but the micrometer head can be raised to accommodate work up to 3/8-in. thick. Anvils are made of hardened steel and may be of any dia. from 1/64 to 5/16 in. with

The Model K Electronic Micrometer measures materials 0.001-in. thick accurately to 20 millionths of an in.

flat or spherical surfaces. Anvil pressures vary from 1/4 oz. to 1 lb. However, the standard combination of anvil size and anvil pressure is a 1/8-in. flat anvil and 2-oz. anvil pressure with anvils lapped flat and parallel to 10 millionths.

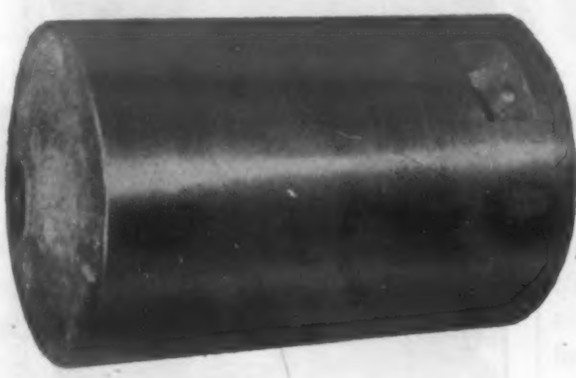
To operate the instrument, the lower anvil is retracted by a lever at the side of the instrument. After the work has been inserted, release of the lower anvil against the surface of the work lifts the upper anvil by the thickness of the work between the anvils. The distance the upper anvil is lifted is measured by the micrometer dial, but the exact setting is indicated by a light on the panel of the electronic unit.

"MEEHANITE® castings very satisfactory—providing uniformity and machinability"

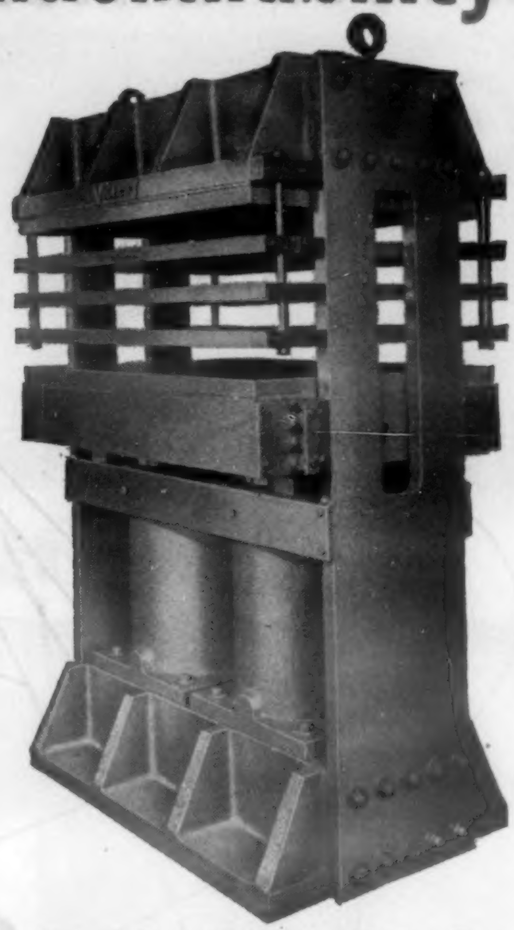


Crossheads for single presses.

Moving Crosshead for a twin cylinder press.



Finish machined Meehanite ram.



Viceroy Plate Polishing or Molding Press. Platens 36" x 48". Stroke 18"

THE Viceroy Manufacturing Company Limited, West Toronto, Canada, leading manufacturers of platen presses for rubber molding, make the above statement when providing reasons for the extensive use of Meehanite castings in their product.

In their line of presses Meehanite castings are specified for the cylinders, rams, crossheads, grids and bases, as well as for other machinery manufactured by this firm.

In addition to uniformity and machinability, Meehanite castings supply these components with better wear resistance, adequate strength properties and solidity.

Besides these general engineering castings, the same production and metallurgical controls are utilized in the manufacture of the special types of heat, wear and corrosion-resisting Meehanite castings.

For further details on the engineering characteristics available in Meehanite castings write for our bulletin "The Vital Component — Good Castings."

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario

"This advertisement sponsored by foundries listed above."

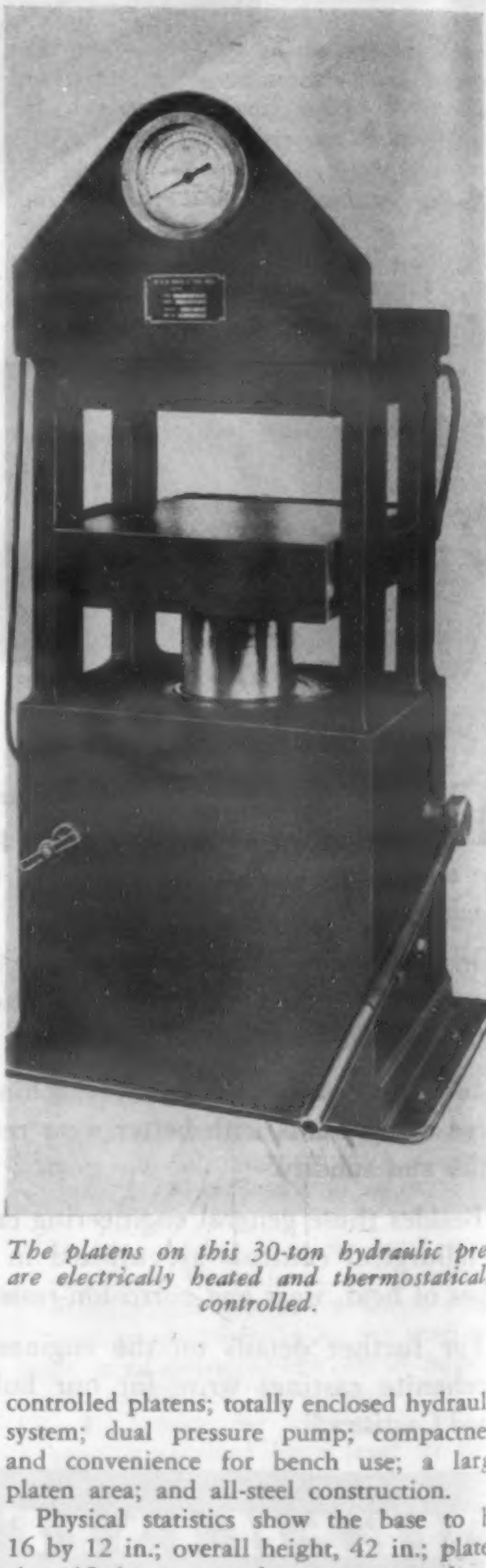
MEEHANITE®

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

30-Ton Press Forms Plastics, Rubber, Powdered Metals

A new 30-ton Hot Plate hydraulic press has been designed by the *N & N Machine Tool Wks., Inc.*, 128 Orono St., Clifton, N. J. This unit is particularly suited for services such as plastic laminating, plastics and rubber molding, forming powdered metals, drawing, embossing, hobbing and similar applications where accuracy, speed and ease of operation are essential to low cost production. It is ideally adapted for use in the rubber industry where an occasional molding press is desired for short run jobs, sample molds and experimental work.

Outstanding features of the new press include: electrically heated, thermostatically controlled platens; totally enclosed hydraulic system; dual pressure pump; compactness and convenience for bench use; a large platen area; and all-steel construction.



The platens on this 30-ton hydraulic press are electrically heated and thermostatically controlled.

Physical statistics show the base to be 16 by 12 in.; overall height, 42 in.; platen size, 12 in. sq.; total pressure on platen, 30 tons; daylight opening, 10 in.; stroke, 6 in. max.; ram dia., 5 in.; and approximate weight; 400 lb.

Die Casting Machine Injects Metal by Air Pressure

Zinc-, lead- and tin-base alloys can be cast with Model AHH-1, a semi-air die casting machine, now in production at the *H. L. Harvill Mfg. Co.*, P. O. Box 177, Corona, Calif.

The machine is a small production model in which the metal is injected by air pressure through an immersed injection piston assembly. Operation of this assembly is more commonly known as the "hot chamber" method. Model AHH-1 casts zinc-, lead- and tin-base alloys into dies through a center gate. After solidification the dies are opened and the castings ejected manually; dies are also closed manually.

A safety-interlock device makes it impossible to inject molten metal into the die cavities again until the dies are locked completely in their closed position. This device fully protects the operator against accidental spraying of molten metal.

A gas burner unit requiring a maximum of 330,000 Btu. per hr. fires the machine. Oil burning units may also be used. A volume of 8 cu. ft. of air per min. is required to operate the machine at its maximum rate of 500 cycles per hr.

Die making is simplified since the ejector box and plate are made a part of the platen of the machine. Dies are made to customer's specifications and tested before shipment so that a machine fully equipped for operation may be obtained.

Chromium-Base Concrete Withstands 3100 F Temperature

Kromecast, a high-strength, chromium-base refractory concrete that withstands temperatures to 3100 F has been developed by the *Refractories Div., Babcock & Wilcox Co.* The new product is of importance for industrial furnaces because it introduces an easily installed concrete combining the refractory and slag resisting properties of chromium-base materials with the ability to support loads at high temperatures.

While the refractory and slag-resisting properties of chromium ore have long been recognized, its installation in plastic form by ramming and pounding required considerable time and labor. However, Kromecast can be installed in a fraction of the time required for plastics and, because of its strength at elevated temperatures, can be used to construct vertical walls and roof arches in many types of furnaces that had to be made of less resistant materials.

Recommended uses where Kromecast will cut down construction time, reduce furnace maintainance and contribute to longer sustained operating periods include: furnace walls, hearths and floors in metal heating and forging furnaces; car tops; electric furnace roofs; water-cooled boiler furnaces operating at high temperatures; furnace door and frame linings; patching furnaces which have been damaged; and forming special shapes quickly and inexpensively.


CUT Your SLICE OF TOMORROW'S MARKET
Keep your cutlery on the top rung of the sales ladder by keeping it smart and durable. Use the right grade of steel, and *know* it's the best for your job. Use Sharonsteel!
Sharonsteel's metallurgists are specialists in producing the finer grades of cutlery steels. Chrome Vanadium, Chrome Moly, Chrome Vanadium Moly, High Carbon Stainless (16/18% Chrome with Moly) and special High Carbon Alloys are all carefully produced to assure the correct selection for your product's BEAUTY and reputation. You can depend on Sharonsteel for the best.
For a more salable product use a more durable steel. Use SHARONSTEEL!
A GOOD COMPANY
MAKING GOOD STEEL
FOR GOOD CUSTOMERS
SHARONSTEEL
NATIONAL
CUTLERY
WEEK
MAY·16·22·

Machine Attachment Eliminates Costly Set-Up Changes

The scope of vertical milling machines and other machine tools is increased considerably by a new auxiliary horizontal milling attachment manufactured by the *Bemis & Call Co.*, Springfield, Mass. This new milling head increases the productivity of these machines mainly by eliminating costly set-up changes. Adjustable to nearly any position, it handles precision milling, drilling and boring at any angle, making

This auxiliary milling head makes it possible to do all the necessary machining with the original set-up.

it possible to do all the necessary machining with the original set-up.

The attachment accommodates one or more cutters up to 4 in. in dia., and will take a standard chuck of ½-in. capacity for drilling, boring and reaming at a 90-deg. angle to the drive shaft. The device is precision-built; has a gear ratio of one to three; and is easily and quickly installed and dismounted.

New Welding Electrodes

Machinable electric welds at amperages in the 45-140 range can now be made on cast iron with a new electrode reported by *All-State Welding Alloys Co., Inc.*, 96 W. Post Road, White Plains, N. Y. Known as All-State No. 4 Fully Machinable Cast Iron Electrode, it can be used on either a.c. or d.c. and is obtainable in dia. of 3/32, ⅛ and 5/32 in.

This electrode has a nickel core and is recommended for use on cast iron wherever free machinability and perfect color match are required. One of its outstanding features is its freedom from spatter. On certain castings it has a greater affinity for the parent metal than a copper-nickel electrode. It is especially recommended for the

repair of cylinder heads and motor blocks because of the low amperage required and the ductility that is obtained in the weld.

The *Westinghouse Electric Corp.*, E. Pittsburgh, Pa., has introduced 27 new Flexarc stainless steel electrodes covering the complete range of types and dia. (1/16, 5/64, 3/32, ⅛, 5/32, 3/16, and ¼ in.) required for all commercial grades of chromium, nickel and straight chromium steels.

These electrodes are produced in two popular types: a combination Titania-Lime type coating suitable for welding with a.c. and d.c. reverse polarity; and, a straight lime type coating for welding with d.c. reverse polarity only. Each of these types is suitable for welding in all positions in dia. 3/16 in. and below, and each meets the requirements of the new AWS designation A 5.4-46T, ASTM designation A 298-46T tentative specifications for chromium and chromium nickel steel welding electrodes where applicable.

Characteristics of these stainless steel electrodes are the fine smooth bead finish with relatively flat contour, smooth action with extremely low spatter loss, and excellent slag characteristics resulting in correct bead formation and easy cleaning.

Measuring Gage Records Dimensional Quality of Work

The Model 500 recording gage, sold exclusively by *Federal Products Inc.*, 1114 Eddy St., Providence, R. I., is a precision instrument for measuring small parts and simultaneously recording in ink, on a paper chart, the deviation of measured pieces from the specified dimension.

The instrument consists of a standard micrometer head driven through a constant torque device and linked to a recording pen. Force to drive the instrument mechanism is applied by means of a lever that may be either hand or foot operated.

Accuracy of measurement is determined by the accuracy of the micrometer head. The constant torque drive essentially removes the human element; this assures greater consistency than can be obtained by manual use of a micrometer. Recording speed is comparable to that of a go, no-go gage, with the advantage that both the amount and direction of error are shown and recorded.

The dots comprising the records of measurements are distributed about the zero center graduation on the chart. A constant ratio of 150:1 exists between the measuring and recording elements; for example, a deviation of 0.001-in. in dimension of the test specimen produces a change of 0.150-in. in the position of the record dot.

Although the instrument is particularly suited for modern statistical quality control, it is applicable to any dimensional inspection work because it gives a continuous visual picture of the dimensional quality of production work.

Isn't low unit cost your ultimate objective? You get more speed and output on long production runs and at lower maintenance cost with the superior quality of Talide Dies. Talide Dies out-perform and out-wear steel dies 20 to 100 times. Talide (the hardest metal made) saves up to 50 hours polishing and redressing time on a single die. And, since Talide Metal takes and imparts the smoothest finish possible, surface defects are practically eliminated. Purchase Talide (tungsten carbide) Dies in any practical shape and of inside diameter up to 24".

Write for Die and Wear Part Catalog 46-WP.

TALIDE METAL MEETS EVERY REQUIREMENT

SINTERED CARBIDES · METAL CARBIDES CORPORATION · MC TALIDE · YOUNGSTOWN, OHIO · HOT PRESSED CARBIDES

METAL CARBIDES CORPORATION

YOUNGSTOWN 5, OHIO *Pioneers in Tungsten Carbide Metallurgy*

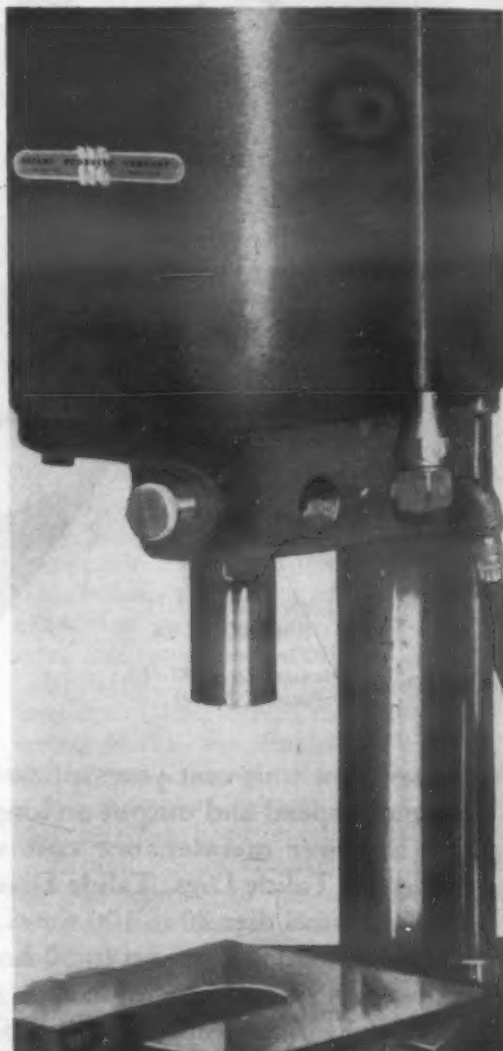
CUTTING TOOLS · DRAWING DIES · WEAR RESISTANT PARTS

Air Hammer Has Wide Impact Range

A bench-type air-hydraulic hammer that operates on the "exploded air" principle is being sold by the *Bryant Products Distributing Co.*, 297 W. Michigan Ave., Jackson, Mich. To operate the hammer, air under high compression is equalized on both sides of the piston. When the air below the piston is released suddenly, an impact ranging from 1 oz. to 12,000 lb. results from a constant 100-lb. line pressure.

This hammer is ideal for light stamping and forging, trimming, molding, crimping, coining, riveting, piercing, staking and forming of production work up to ¼-in. mild steel rivets.

The Bryant hammer displays numerous advantages over larger, heavier and more expensive mechanical presses used to perform the same tasks. First, operation is opposite to that of the mechanical press where the stroke is set to fit the job and impact varies only with the press capacity.



This air hammer produces impacts ranging from 1 oz. to 12,000 lb. from a constant 100-lb. line pressure.

In the Bryant press, stroke is constant and impact pressure may be varied precisely up to the press capacity. Impact pressure then remains the same at any point along the stroke. Next, breakdowns due to variation in stock thickness or to improper positioning are eliminated by this feature. Finally, the cushion of air behind the hammer takes up shock and the stroke accommodates off-

size pieces without damage to work, dies or hammer, thus eliminating costly and time-consuming layups for press repair or die replacement.

Plastics Injection Molding Machine Has 40-Oz. Capacity

Announcement of a new large capacity thermoplastic injection molding machine comes from the *Hydraulic Press Mfg. Co.*, Mount Gilead, Ohio. This machine, one of the largest single nozzle injection machines built to date, was designed specifically to broaden the scope of plastics mass production so as to include items such as refrigerator parts, large radio cabinets and similar large area parts. It is capable of molding all types of thermoplastic materials; however, vinyl-vinylidene chloride requires a special alloy heating chamber. Molding capacity of this machine is 40 oz. of acetate or 32 oz. of polysterene per cycle.

The H.P.M. 40-oz. injection machine is entirely automatic; only removal of the molded parts is required of the operator after they have been automatically ejected from the mold. In short, four simple operations transform the raw plastics material into the finished molded part. First, the mold is closed and tightly clamped. Secondly, the molding material, placed in the hopper of the machine, is fed in measured quantity into a two-zone electrically heated chamber where it is plasticized. Then, a hydraulically actuated plunger injects the plastic material into the closed mold. Finally, after a predetermined chilling period, the mold opens automatically and ejects the molded part.

A distinctive feature of this machine is a new mold clamp that consists of a large hydraulic double-acting ram fitted with a small internal booster ram for fast closing of the mold. Die slam is eliminated through automatic slow-down which takes place just prior to mold contact. The mold opens slowly until the molded part releases itself from the stationary mold half, then mold travel is rapid. Speed is again retarded prior to ejection of molded parts to protect them from damage. These slow-downs can be used at the option of the operator.

High-Speed Automatic Device Stamps Seamless Tubes

Manufacturers of seamless and light-wall aluminum, copper and brass tubing can efficiently mark their products at production-line speed by using a new device offered by *Pannier Bros. Stamp Co.*, 211 Pannier Bldg., Pittsburgh 12, Pa.

The "Master Marker" stamps 1, 2, 3 or 4 sides on the same run at a rate up to 300 ft. per min. Bars as well as tubing

(Continued on page 140)

in round, square, hexagon and other shapes can be handled in sizes from 3/8- to 2-in. dia. Equipped with a 1/3-h.p. motor, this device can be used for production on job work. The market has replaceable segments and interchangeable type with character size depending on requirement of the product marked.

The weight of the "Master Marker," which comes as a portable or stationary unit, is about 700 lb. complete.

Pipe and Tubing Cutter Has Automatic Features

Power-driven rollers, automatic stop-start action and ball bearing operation throughout are unique features of the new high-speed E-Z CUT pipe and tube cutter manufactured by the *Quijada Tool Co., Inc.*, 5474 Alhambra Ave., Los Angeles 32, Calif.

This fully portable machine simplifies and speeds up pipe and tube cutting operations in diameters ranging from 3/8 to 4 in. Cast iron pipe within the same range of sizes can also be cut.

A 1/2-h.p. motor furnishes direct gear drive to the rollers of this machine instead of the cutter wheel.

An integrally-mounted, 1/2-h.p., 110-v., universal type a.c.-d.c. motor furnishes direct gear drive to the rollers instead of the cutter wheel as in conventional machines. An automatic trip-switch starts cutting when the cutter wheel contacts the pipe, and automatically stops when the cut is finished. Adjustable roller yokes provide necessary support for the pipe, yet permit free rotation.

Additional features include self lubricating gears and easy removal of the ball-bearing cutter wheel for sharpening.

Instrument Measures Extent of Metal Polarization

The "Pulse Polarizer" has been developed by *Glenn A. Marsh*, 6059 Waveland Ave., Chicago 34, Ill., for laboratories engaged in corrosion work. The instrument serves two purposes. First, it yields quantitative information on the extent that metals polarize in a given medium. Secondly, it can be used as a rapid means for determining the corrosion rate of metals.

The unit consists of a high voltage pulse circuit, a sensitive electronic potentiometer and a high-speed recorder. It operates by subjecting a metal specimen to a brief but violent discharge, with polarization being recorded both before and after the discharge. The data are reproducible, permanent and distinctive for each set of corrosive conditions.

Recommended applications for the "Pulse Polarizer" are: evaluating inhibitors, choosing proper corrosion resistant alloys, determining corrosiveness of chemicals, and in controlling inhibitor concentration.

● The *LaBahn Machine & Mfg. Co.*, Menlo Park, N. J., recently added a completely new line of stock reels and scrap winders to their present line of automatic roll feeds, stock straighteners and scrapcutters. The additions include more than 25 different models. Reels are available in spoke or disk type; and with plain, automatic brake or motorized spindles. Supported on large cast-iron bases and weighing from 150 to 1000 lb., the reels can be tilted from vertical to horizontal through an arc of 90 deg.

Porous Materials Inspected by Nondestructive Method

Partek, an inspection method recently developed by the *Magnaflux Corp.*, 5900 Northwest Highway, Chicago 31, Ill., eliminates wasted kiln time resulting from firing defective ware. This method quickly detects minute surface and sub-surface cracks in porous or unfired ceramic products; it is also used on powdered metal "compacts" before sintering; and finish fired porous insulators or porous metal bodies.

The Partek method of inspection is simple. Processing can be either manual or automatic. The surface of the clay body is momentarily flushed with a liquid suspension of Partek particles that will adhere to any cracks by differential filtering action between the crack and the unbroken surface. Indication of cracks is permanent until the body is fired in the kiln.

Indications may be either brightly colored, to contrast with the body; or fluorescent, to mark each defect as a luminous white line when viewed under a black light. Fluorescent Partek indications are particularly advantageous where rapid inspection is desired, as in high volume plate manufacture.

New Coating Materials

A new material that prevents rusting when deposited on metal surfaces as a thin, clear film has been introduced by the *Kano Laboratories*, 75 E. Wacker Drive, Chicago 1, Ill. Sold under the name of Kano Rustproof, this product is applied cold by dipping, spraying or brushing, and dries in about 15 min. to a clear, hard, dry surface that is tough, flexible and nonporous.

Kano Rustproof can be removed with any petroleum solvent although it is not necessary to remove it prior to painting. The fact that it is hard and dry permits coated stock to be handled. Under normal indoor conditions this material offers protection for periods up to 6 months or more; for more severe conditions it can be removed and replaced at regular intervals.

The *DuBois Co.*, Cincinnati 3, Ohio has marketed a new paint spray compound known as New Pigmented Filmite that is a ready-to-use spray-on or brush-on liquid. This product is a booth masking compound that will dry white for maximum light reflectivity and will form a firm, non-tacky, non-greasy surface for resistance against impact. It is especially suitable for non-slip clinging to overhead areas under heavy overspray load and for masking floors. Additional features of Filmite are that it will not flake, crumble or dust and it is heat resistible, making it applicable for booths near ovens.

Filmite is completely water washable, making it a relatively simple matter to wash away the dried paint overspray with hot or cold water. The overspray can also be easily peeled or scraped off.

The Monsanto Chemical Co., St. Louis 4, Mo., has a new, economical vinyl resin coating that combines flame-resisting qualities with exceptional abrasion and weathering characteristics. Named Ultrasol, the new product produces either a smooth, colorful finish or a decorative leather-like effect when applied to paper or fabric.

Superior properties of vinyl resins have been recognized for years, but the application from low solid content solutions was too expensive for general use. Ultrasol, it is claimed, now allows vinyls to compete with the most economical coating materials.

New Contact Wheel Improves Abrasive Belt Polishing

A new contact wheel for abrasive belt polishing has been introduced by the *Devine Bros.*, 200 Seward Ave., Utica 1, N. Y. This wheel, called Beltflex, has been designed to eliminate the necessity for using buff sections under abrasive belts. Besides having the same advantages as buff sections, the Beltflex wheel also has balance and density and a smoothly ground surface that makes for uniform belt tracking.

Wheel density is available in two types: (1) Type E, which offers exceptional flexibility; and (2) Type G, which combines flexibility with agressive cutting action. In performance, the flexibility of these wheels

allows for high quality, light contour work. In addition, the wheels are balanced to run smoothly and truly, and constantly apply accurate pressure to the working surface.

Machine Welds to Any Outline

The WM-6, a machine for making welds to any outline, has been announced by the *Linde Air Products Co.*, Unit of *Union Carbide & Carbon Corp.*, 30 E. 42 St., New York, N. Y. Operating by the submerged-melt welding process, this machine is used to carry a Unionmelt welding head and guides the head through any desired contour by use of a strip templet.

The type U welding head has a maximum current capacity of 2000 amp. and can weld material from 18-gage to 1¼-in. plate in a single pass. Heavier parts of almost any thickness can be welded by a suitable number of passes.

The machine will operate over an area 34 in. wide and 80 in. long. Sections can be added to the tracing table so that any length can be covered. The welding speed is adjusted by a stepless speed control on the tracing machine; standard or high-speed tracing heads make it possible to weld at speeds from 4 to 40 or 11 to 100 in. per min.

Welding domestic fuel-oil tanks with the WM-6 shape-welding machine.

There's a Du Pont Molten Salt Bath for Any Type of Case Hardening

Case Depth Desired	Recommended Bath	Temp. °F	NaCN %	STARTING COMPOSITION	REPLENISHING COMPOSITION
0.003" to 0.010"	PLAIN CYANIDE	1400 to 1600	20-30	30 or 45% CYANIDE-CHLORIDE MIXTURE, "CYANEGG" and NaCl, and/or Na_2CO_3	45, 75 or 96% NaCN—depending on dragout loss
0.005" to 0.040"	DU PONT ACCELERATED SALT WS with Graphite Cover	1500 to 1650	18-25	1/10 ACCELERATED SALT WS plus 9/10 Du Pont Case Hardener 30% NaCN	ACCELERATED SALT WS In some cases, supplemented with 30% and/or 96% NaCN
0.025" to 0.090"	DU PONT CARBURIZING SALT with Graphite Cover	1650 to 1750	6-12	1/3 CARBURIZING SALT plus 2/3 HEAT TREATING SALT No. 6	CARBURIZING SALT

EACH OF THESE BATHS is designed to produce cases of desired depth in the shortest possible time at the lowest possible cost. Yet they're but three of many Du Pont heat treating products that will return top production for you with maximum economy. Du Pont technical men will work with you in selecting the right materials to meet specific needs. For more information or technical assistance, write or call our nearest district office. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

DISTRICT OFFICES: Baltimore, Boston, Charlotte, Chicago, Cincinnati, Cleveland, Detroit, El Monte, California, New York, Philadelphia, Pittsburgh, San Francisco.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Tune in to Du Pont "Cavalcade of America" Monday nights—NBC Coast to Coast

DU PONT CYANIDES and SALTS

for Steel Treating

News of...

ENGINEERS
COMPANIES
SOCIETIES

Engineers

Dr. *Harry A. Schwartz,* director of research, National Malleable & Steel Castings Co., will address the Institute of British Foundrymen in London June 9 on "Solved and Unsolved Problems in the Metallurgy of Blackheart Malleable." The letter which invited him stated: "Recognizing as we do in this country the tremendous contribution you have made in the malleable industry, we feel that there must be much which you wish to put into a lecture of this kind, and which would make it of great value."

Otto Krauss has been appointed chief engineer of Gerity-Michigan Corp. He was previously chief die cast engineer for Johnson Motors Div., Outboard Marine & Mfg. Co., Waukegan, Ill. In his new position he will supervise all technical phases of die casting at the company's Detroit plant.

Robert A. Lubker has been named assistant chairman of metals research activities at Armour Research Foundation, Illinois Institute of Technology, according to William E. Mahin, chairman. Before joining Armour two years ago he was with Westinghouse, in charge of nonferrous metallurgical engineering. *Walter C. Troy* has been made supervisor of heat treating research, having joined Armour over a year ago with a background of over 10 years of industrial and metallurgical experience. Dr. *Julian Glasser* has also been appointed to the staff of metals research, having formerly been director of research for the General Abrasive Co. *Charles Locke,* formerly chief metallurgist and foundry superintendent, West Michigan Steel Casting Co., has also joined metals research. *Roy D. Hayworth,* who joined metals research in 1946, has become supervisor of abrasion research. Dr. *Haldon A. Leedy,* chairman, physics research at Armour, is now acting director of the foundation, succeeding Dr. *Jesse E. Hobson,* who accepted directorship of the Stanford Research Institute.

William H. Schuster has been appointed welding supervisor at New York for American Car & Foundry Co. He has been with several prominent companies such as Westinghouse and Lincoln Electric Co., and is author of "Arc Welding Instruction Manual" for shipyard welders (1941).

Ann E. Hamilton has been appointed

Cuts Beam Cost $2.57 to 71 cents with Arc Welding

By G. C. Weiland
The Schaffer Poidometer Company
Pittsburgh, Pa.

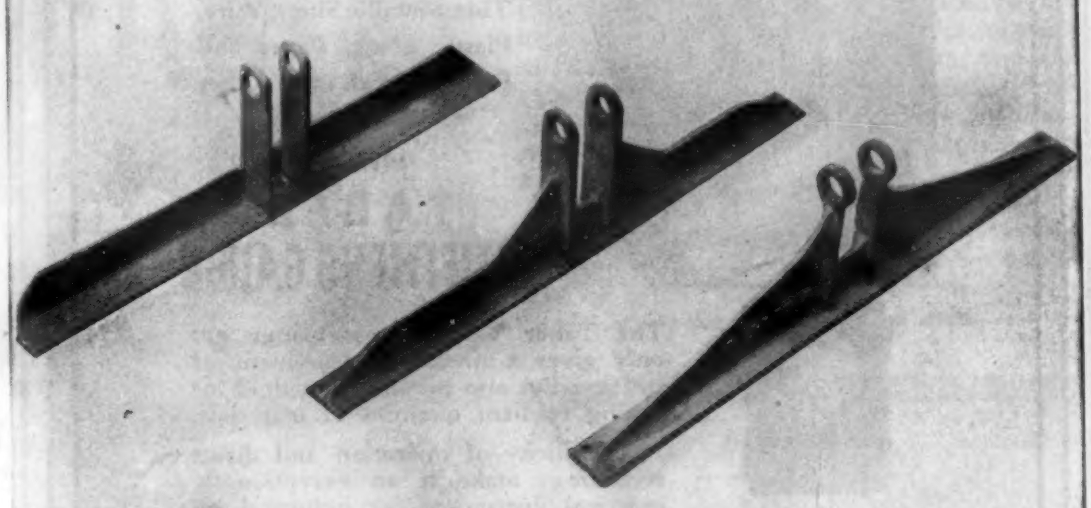


Fig. 2. Progressive redesign of scale beam to welded construction. Right: Original beam . . . Cost $2.57. Center: First design change . . . Cost $1.63. Left: Present design . . . Cost 71 cents.

SUBSTANTIAL savings in manufacturing costs are readily possible through a careful design study of component parts for arc welded construction. This fact is well supported by our recent experience with a scale beam originally costing us $2.57 to produce. Redesign for arc welded assembly has cut the cost to 71 cents, and the weight 25%. In addition, the performance of our product has been improved and the appearance greatly enhanced for better sales appeal.

Our product, the Poidometer (Fig. 1), is a continuous weighing machine. It incorporates a moving belt carrying the material to be weighed. A roll directly below the conveyor belt takes the direct load of the material, transmitting the load force to a balance scale through a beam member (Fig. 2) acting as a fulcrum.

Pressed with a demand urgency for our weighing machines during the recent years plus a supply problem of securing parts for our original construction, led us to redesign the scale beam member. The first redesign followed the pattern of the original casting shape and cut the manufacturing cost of this scale beam from $2.57 to $1.63.

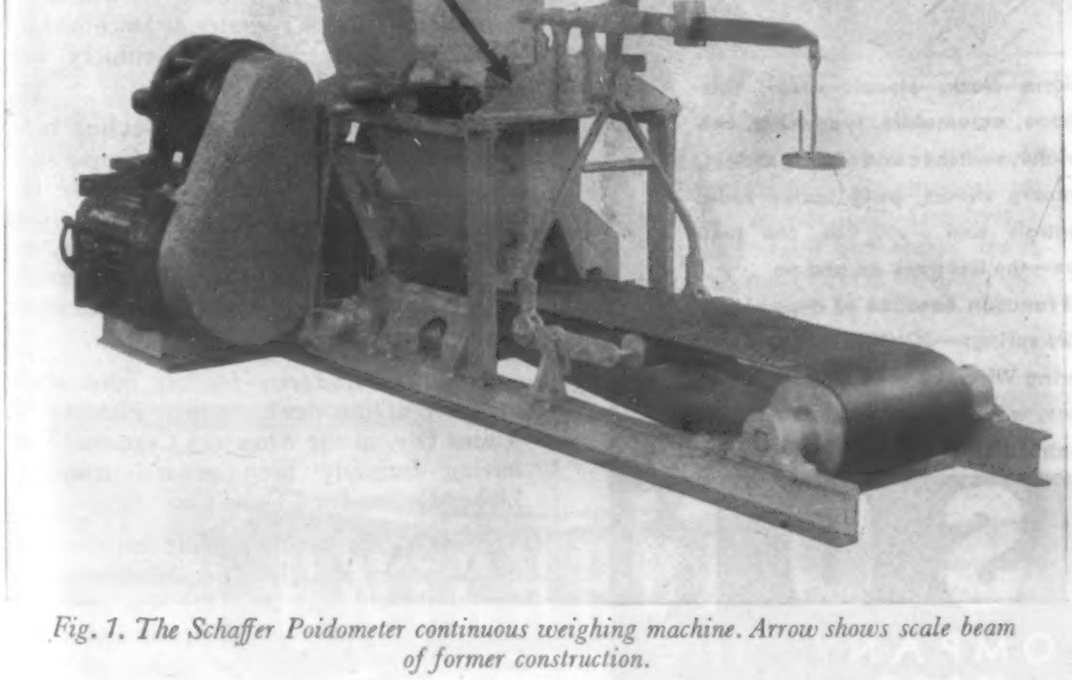


Fig. 1. The Schaffer Poidometer continuous weighing machine. Arrow shows scale beam of former construction.

Further study of this component part along with the suggestions of a Lincoln design engineer, prompted a second change. This change greatly simplified our design by incorporating two formed steel straps arc welded to an angle piece as shown in Fig. 2. With this latter design, our production cost is cut to 71 cents and a weight reduction is made from an original 10 pounds to 7 pounds.

In addition to the above savings, the change to welded construction eliminates 0.28 man-hours per beam for several machining operations that are now cut out entirely.

News of... ENGINEERS COMPANIES SOCIETIES

sales promotion manager, Ajax Electric Co., Philadelphia.

Jan M. Krol, consultant in foundry practice and development engineer in hot-pressing and vacuum techniques for the cemented carbide field, and *Robert Lane Pettibone,* specialist in the heat treatment of powder metal parts, have joined Sintercast Corp. of America, as chief metallurgical engineer and research metallurgist, respectively. Mr. Krol studied and worked in several European countries, while Mr. Pettibone has specialized in brazing and improvement of powder metal parts through heat treatment.

Dr. *H. B. Osborn, Jr.,* has been made technical director, Tocco Div., Ohio Crankshaft Co., and will explore and develop new fields for induction heating equipment. He will investigate especially the fields of chemical industry, heavy forgings and high production soldering. He is both a lecturer and author of technical papers.

I. J. Barber, director of engineering, Fostoria Pressed Steel Corp., Fostoria, Ohio, has been promoted to vice president of the company. He has been responsible for developing the design and technique for applying the infra-red equipment of Fostoria. He has addressed many meetings on the subject of infra-red practices.

Alex F. Blackwood, for 12 years metallurgical and sales engineer, A. F. Holden Co., has resigned to form a partnership with *J. W. Frazier,* formerly metallurgical engineer, Jack & Heintz Precision Industries, Inc. The partnership will serve as metallurgical sales engineers and consultants for Crown Chemical Corp., John Ek Industries, Inc. and Upton Electric Furnace Div., Commerce Pattern Foundry & Machine Co., in Ohio, West Virginia, Kentucky and Western Pennsylvania.

William P. Good, former welding technician, Mid-States Equipment Corp., Chicago, has been appointed head of the department of applied welding engineering, that corporation, while *Virgil Carlson,* recently returned from Government service, is the new director of the electrical engineering department.

James L. Rodgers, Jr. has been made manager of the newly formed Plastics and Resins Div. of the American Cyanamid Co., having formerly been general manager, Libbey-Owens-Ford Glass Co.

Louis X. Ely has been made consultant to the Monessen Foundry Div., Monessen, Pa., Rockwell Mfg. Co. Mr. Ely was once the owner of the Monessen company and under his direction became the maker of high grade, thin section, pressure-tight gray iron, semi-steel, brass and bronze castings.

Dr. *John T. Rettaliata,* director of mechanical engineering at Illinois Institute of

News of... ENGINEERS COMPANIES SOCIETIES

Technology, will become dean of engineering Sept. 1, 1948. At 36 he will thus become one of the youngest deans of engineering in the United States. A leading mechanical engineer and gas turbine expert, he has headed his department since 1945. He is a recipient of the Pi Tau Sigma gold medal award for outstanding achievement, and has authored 17 publications.

R. R. Tatnall has been appointed field service metallurgist for the Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div. He was awarded honorable mention by the Wire Assn. for his paper, "Fatigue Properties of Springs."

Julius W. Marx has been made chief engineer, Newcomb-Detroit Co., builder and installer of dust arresting equipment and finishing systems. He became experienced with this type of equipment as plant engineer at General Motors Truck & Coach Div.

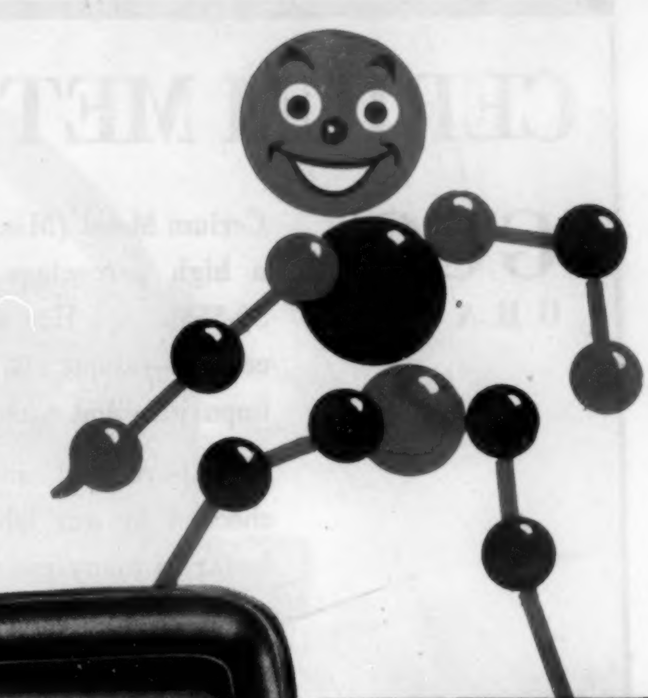
Howard C. Wolf succeeds *Richard F. White,* retired, as assistant to the president, Mullins Mfg. Corp. During the late war Mr. Wolf served four years with Army Ordnance and received commendation for redesigning cast and forged ordnance parts to mass produced stampings. Mr. White had been with Mullins for 26 years.

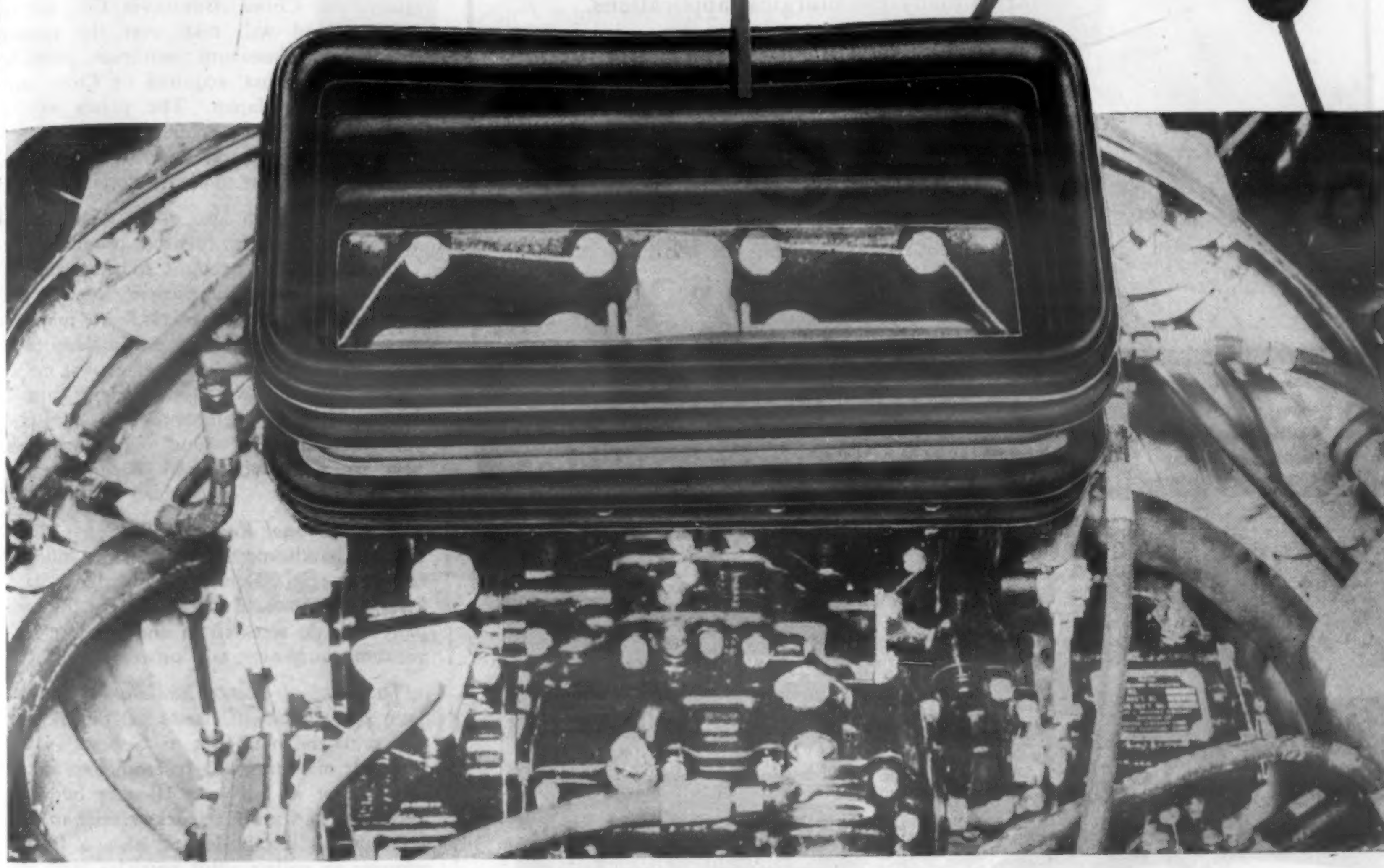
Dr. *John A. Hutcheson* has been named director of the Westinghouse research laboratories, succeeding Dr. *L. Warrington Chubb,* who has been named director emeritus. For four years Dr. Hutcheson had been associate director. During the war he supervised the engineering of all radio communication and radar equipment produced by Westinghouse. When peace came Dr. Hutcheson became chief advisor on atomic energy research within Westinghouse.

Charles J. Reimer, formerly procurement metallurgist for SKF Industries, Inc., has been made general purchasing agent. Before joining SKF in 1944 he was connected with forge shops and steel ordnance manufacturers.

Russell H. McCarroll, director of chemical and metallurgical engineering and research for the Ford Motor Co., Detroit, died suddenly at Bay City, Mich. on March 31 while on a trip looking for a prospective fishing camp. He had been employed by Ford since 1915 and is credited with developing 50 processes, most of them in metallurgy. He also engineered improvements on the production line. Rising rapidly, in 1944 he became executive engineer in charge of all chemical and metallurgical work and in 1946 became executive engineer. He was prominent with the Society of Automotive Engineers, the Detroit Engineering Society and American Foundrymen's Assn. Besides his regular work he performed many experiments to expand the use of farm products.

Where PERBUNAN helps 4,800 horses breathe!





THE FLEXIBLE COUPLING shown above is a mighty important item on the 4800 horsepower Pratt & Whitney engines used in the new Convair-Liner commercial transports.

It connects the air duct to the carburetor...carries in the tremendous feed of air needed for proper gasoline mixture. It has to have hot-temperature dependability...high resistance to oil and high octane gasoline...and lend itself to precise fabrication.

PERBUNAN NITRILE RUBBER was selected for this vital coupling after engineers of Consolidated Vultee and the technicians of Los Angeles Standard Rubber, Inc. ran many exhaustive tests and found Perbunan best suited for the job.

For rubber that resists oil, heat, abrasion and water...holds delicate colors...and stays flexible at low temperatures... write our nearest office.

PERBUNAN
REG. U.S. PAT. OFF.

THE RUBBER THAT RESISTS OIL, COLD, HEAT AND TIME

ENJAY COMPANY, INC. 15 West 51st Street, New York 19, N. Y.; First National Tower, 106 South Main Street, Akron 8, Ohio; 221 North La Salle St., Chicago 1, Illinois; 378 Stuart Street, Boston 17, Massachusetts. West Coast Representatives: H. M. Royal Inc., 4814 Loma Vista Avenue, Los Angeles 11, California. Warehouse stocks in Elizabeth, New Jersey; Los Angeles, California; Chicago, Illinois; Akron, Ohio; and Baton Rouge, Louisiana.

News of...
ENGINEERS
COMPANIES
SOCIETIES

Companies

The Chinese National Government has approved a contract with *Reynolds Metals Co.* to operate an aluminum industry in China on a partnership basis. A new company, the *China Aluminum Co.*, will be formed and will take over the alumina plant and aluminum reduction plants in Taiwan, Formosa, acquired by China upon surrender by Japan. The plants will be rehabilitated and expanded, and will furnish China with aluminum and have a surplus for export to obtain dollar exchange.

Use of oxygen and other modern techniques of electric furnace production of stainless steel is brought to the screen in full color in a motion picture, "Melting and Refining of Modern Steels," 16 mm., released by the *Allegheny Ludlum Steel Corp.* It is a story of stainless steel as it is melted in an ultra-modern 50-ton electric furnace, lasting 20 min. Telephoto lenses are used for interior shots. One may obtain the film from the company's headquarters at Pittsburgh 22.

The *National Research Corp.* has moved into its handsome new three-story building on Memorial Drive, Cambridge, Mass., known as "Research Row." Here the company will do research in and produce high vacuum equipment and processes.

The *United States Radiator Corp.* has completed what it claims is the highest cupola in the nation at its Geneva, N. Y., plant. It measures 115 ft. from base to top of stack, or as tall as a 10-story building. It is equipped with a spark-arrester to protect surrounding buildings; also, a fly ash remover to collect solid particles from the gases and a skip hoist for economical loading of the cupola charges. It replaces a 30-year-old, 65-ft. cupola.

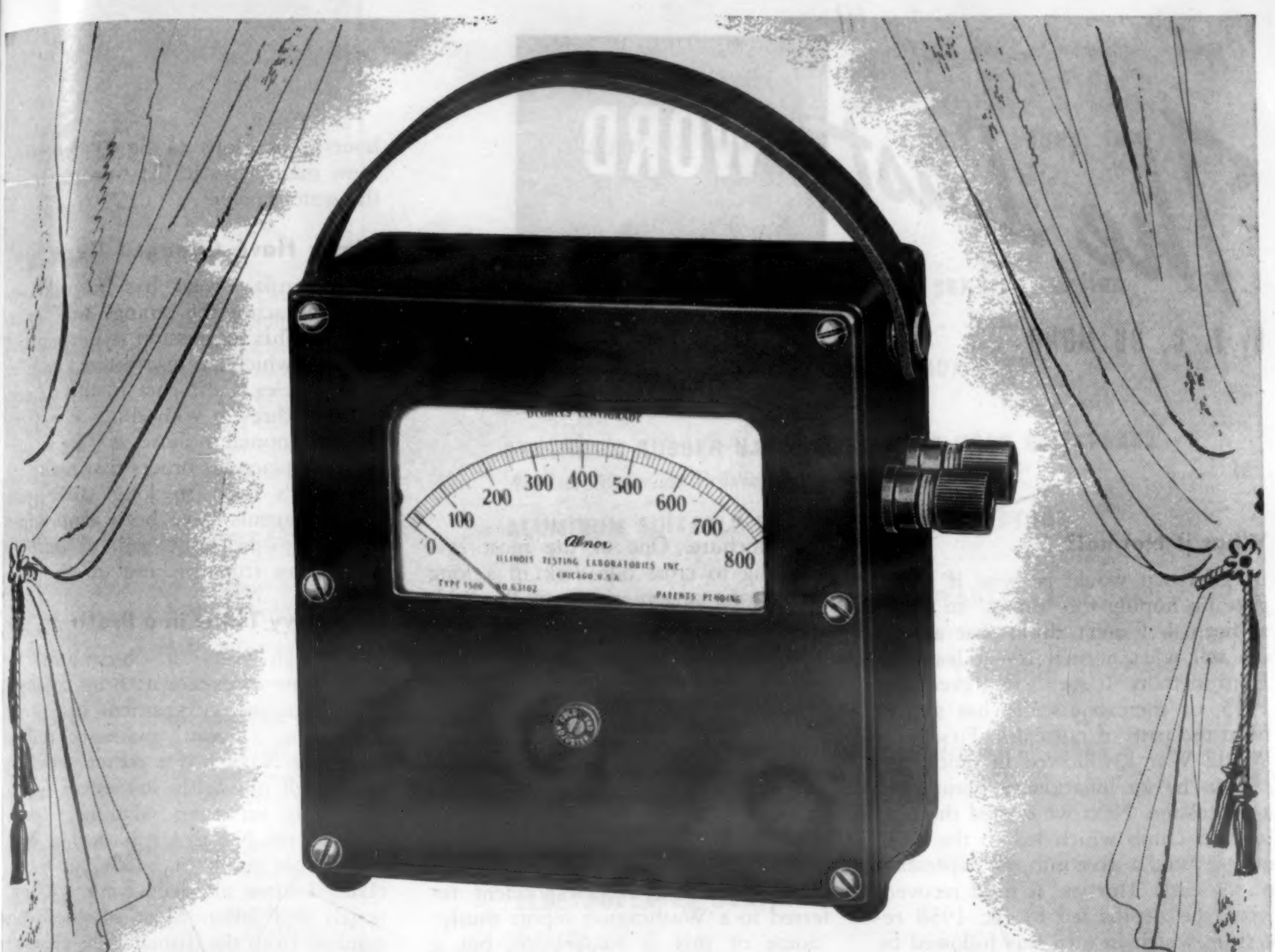
A new, modernly-equipped laboratory building for studying pilot castings and developing suitable foundry techniques is in full operation at *Michiana Products Corp.*, Michigan City, Ind. Featuring the new equipment is a 250,000-volt latest Picker X-ray, which penetrates 2 in. of metal.

Sam Tour & Co., Inc., engineers, metallurgists and consultants, are expanding laboratories and workshops, having acquired two and a half more floors at 44 Trinity Place, New York, a total of seven floors.

The *Dow Corning Corp.*, Midland, Mich., which has just established a branch office at Dallas, Texas, has doubled its production of silicones since V-E Day.

The *Phosphor Bronze Corp.*, Philadelphia, has bought the assets of the *Phosphor Bronze Smelting Co.*

(Continued on page 158)


0
100
200
300
400
500
600
700
800
Alnor
ILLINOIS TESTING LABORATORIES INC.
PATENTS PENDING

The Last WORD

by T. C. DU MOND

What is Normal?

Perhaps it would be wise if we all gave up hoping for "things" to return to normal. I don't think that anyone can tell what normal is—at least not from memory. It seems that ever since 1915, or thereabouts life has strayed from the path of normalcy. First came World War I, followed in quick succession by an inflationary period and a depression. Next we started the long upward climb which led to the crash of 1929 and a dive into the depression of the early Thirties. A mild recovery from the depths led to the 1938 recession which in turn was followed by a war preparatory boom. Recent history needs no retelling. All of this dour thinking comes from the fact that two months ago we had visions of production and demand attaining a relatively normal relationship, only to have a war psychology take hold and upset the apple cart again. The only answer seems to be to keep constantly on the alert in both business and personal affairs.

What Business Are You In?

According to a report issued by Dun & Bradstreet, the machinery manufacturing business was a poor one to be in during 1947—at least from the standpoint of business failures. Last year 285 concerns of this type failed, an increase of 157 over the year previous. The iron and steel industry came through the year with only 76 failures. It looks like the hotel business is (or was) the most healthy, with only 11 failures in the last two years.

Tooting Your Own Horn

For years, the annual reports of large corporations were dull affairs which were likely to frighten off prospective readers. Lately there has been a decided improvement so that even if you don't look at the figures you do leaf through the brochure. One of the most eye-catching to cross our desk in a long time is the current report of Reynolds Metals, which used as a cover thick aluminum foil. Such a cover certainly leaves little doubt as to what the company is trying to sell. A close runner-up in the current crop of reports is that of Consolidated Coppermines, which used a simulated copper cover.

What's That Word?

In a recent letter to this office seeking information, a correspondent referred to a Washington report thusly: "Some of this is *balderwash,* but a great deal of it is authentic." A hasty visit to the dictionary failed to disclose any such word. Two leads were suggested, which may have been mated to give birth to an entirely new word in our language. It could be that *balderwash* is the offspring of "balderdash" (senseless) and "hogwash" (swill). The new word then meaning senseless swill.

Sadistic Pleasure

Probably no publication is immune to typographical errors. Unfortunately, we are no exception, thus it is with fiendish glee that we pounce upon typo's in other places. One such garble recently referred to the manu-fatcuring industries. Could these industries be interested in making lard?

A Fair Day's Work

Like the weather, everybody talks about a fair day's work, but does little about it. That will all be changed soon. The Society for the Advancement of Management is sponsoring a project to determine: "What is a fair day's work." The research will be carried on by New York University's College of Engineering. It will be interesting to learn how such a study can be conducted. Will they measure how tired a man gets? How many yawns per hour he develops as the day goes on? How many trips to the washroom and the water cooler?

Times Have Changed Dept.

California always has been known for embracing the strange and unexpected. This impression is perpetuated by news which has just reached us from Los Angeles. California manufacturers recently threw a wing-ding of a party as a testimonial to those, as they termed it, "who place the orders that make the jobs." It's been so long since purchasing agents have been entertained that they probably had to restrain themselves from picking up the tabs.

The Navy Turns in a Profit

Through years of observation we have come to expect nothing but deficits from any government operation. Therefore, a recent publicity release from the Navy had a rather shocking (although pleasantly so) effect on us. Reporting on scrap salvaging operations by the Naval Air Station at Norfolk, a net profit of $405,424.28 was claimed after all deductions for materials and labor. Most of the scrap resulted from the dismantling of obsolete aircraft.

People in Glass Houses

The old adage about people in glass houses not throwing stones was just a figure of speech since there really were no glass houses. At the risk of becoming monotonous we must again say that today things are different. In addition to glass blocks being used as building materials, we now have houses which present vast areas of porcelain enamel. Those who should know say these houses are quite attractive, but add that it would probably be a poor idea to incur any wrath that might result in the heaving of rocks or "Irish Confetti." Despite all the improvements in porcelain enamel, it can still be chipped if you really put your mind to it.

Steel and Porcelain "Wallpaper"

A fit companion to the porcelain houses is a new "wallpaper" made of porcelain enameled-steel. Soon to be on the market, this new wall covering will come in rolls which can be cut with snippers and glued to any smooth surface with plastic cement. A development behind the development is the perfection of a continuous rolling mill which rolls steel to ultra-fine thicknesses.